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Entomon 1994 Vol. 19 No. 1 & 2 pp. 1 to 5

LIFE-TABLE STUDIES ON *PACHYCREPOIDEUS VEERANNAI* NARENDRAN & ANIL, A CHALCID (HYMENOPTERA: PTEROMALIDAE) PARASITOID OF *EXORISTA SORBILLANS* WEID. (DIPTERA: TACHINIDAE)

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(*Received* 30 *June* 1991)

Life cycle of the parasitoid, *Pachycrepoideus veerannai* of *Exorista sorbillans* is studied. Age specific life-table for *P. veerannai* Nar. & Anil is constructed. The egg, larval and pupal duration lasted for 2—3 days, 10—12 days and 8—10 days respectively. The adult longevity was 20—35 days. Generation time T_c was 29.72 days, rate of natural increase was 0.1133 and net reproduction rate R_0 was 29.

(*Key words:* life table, *Pachycrepoideus veerannai*, *Exorista sorbillans*)

INTRODUCTION

Exorista sorbillans Weid. commonly known as uzifly, is a major pest of silkworm, *Bombyx mori* L. It is a larval endoparasite which prefers to oviposit on III, IV and V instar larvae killing them and causing damage to the extent of 15–20% to the silk industry (MUKHERJEE, 1919; GHOSH, 1949; JOLLY, 1981; KASTURI-BAI *et al.*, 1986).

Biological control, due to its icreased acceptance and popularity forms one of the major approaches that has been used in attempting to contain the uzifly menace. Four species of hymenopteran parasitoids namely, *Nesolynx thymus* (PRADIP-KUMAR *et al.*, 1986), *Trichopria* sp. (VEERANNA *et al.*, 1987a), *Exoristobia philippinensis* (VEERANNA *et al.*, 1987b), and *Dirhinus anthracia* (VEERANNA & JYOTHI, 1988) have been reported to be pupal parasitoids of *E. sorbillans*. In this report yet another parasitoid *Pachycrepoideus veerannai* Narendran and Anil (Hymenoptera : Pteromalidae) has been recorded for the first time on *E. sorbillans*.

MATERIALS AND METHODS

The adults of *Pachycrepoideus veerannai* were found visiting the laboratory where *E. sorbillans* cultures were maintained, but protected from parasitoid infestation. These flies were collected and were fed on honey and sucrose solution in aqueous medium soaked on cotton pads. *E. sorbillans* pupae were exposed to *Pachycrepoideus veerannai* adults to observe the existence of parasitism. The parasitoid readily oviposited on the host *E. sorbillans* pupae and successfully completed the life cycle. These studies were conducted at room temperature. The temperature and humidity recorded in the laboratory ranged from 23–29°C and 60–85% respectively.

A life-table study was conducted with five mated females of *Pachycrepoideus veerannai*. Each parasitoid was placed individually in a 250 ml conical flask and provided with a mixture of 50% honey and 10% sucrose solution. These flies were provided with 50 host pupae individually every 24 hours, until the death of

the females. The parasitised hosts were reared day-wise separately in 250 ml conical flasks unitl adult emergence. Age specific life table was constructed and life-table statistics were derived using the formula

$$T_c = \frac{\Sigma x . l_x m_x}{\Sigma l_x m_x}$$

r_c = ln R_o / T_c and

$\lambda = e^{r_c}$, where x = Pivotal age in days; l_x = age specific longevity; m_x = age specific fecundity; R_o = net reproductive rate; T_c = approximate duration of generaton; r_c = capacity for increase; λ = finite rate of increase.

OBSERVATIONS AND DISCUSSION

Preliminary observations made on *Pachycrepoideus veerannai* revealed that the female fly is comparatively bigger than males (Figs. 1 & 2). The female has a broad and pointed abdomen. The male has a narrow abdomen with blunt end. The female mates only once in her life time. The male exhibits a very typical pre-mating behaviour of following the female with the wagging movement for about five to ten minutes and holds the back of the female with the antennae and mates. The duration of mating is 2–5 minutes. The female alights on the uzi pupa soon after mating, probes the surface of the host with the antennae and abdomen, pricks the host puparia with the ovipositor and inserts the ovipositor to deposit the eggs. It is a solitary ecto-pupal parasitoid. The eggs hatch 2–3 days after oviposition. The larvae of *Pachycrepoideus veerannai* are vermiform and larvae are ecto-parasitic. The larval and pupal duration range from 10–12 days and 8–10 days respectively. The type of pupae is exarate. Metamorphosis is completed in the host puparia and adult fly emerges out of the infested host by cutting the pupal case. The adult life span is 20–35 days. The infestation is successful only if the host is between 1–7 days of pupal stage. The infestation is not found on larvae of both uzifly and different developmental stages of moth of silkworm.

The data on the age specific longevity and fecundity are presented in Table 1, while life table statistics are presented in Table 2. The female lives for 20–45 days. Maximum fecundity is observed during fourth day. The age specific fecundity was reduced considerably after 12 days.

The net reproduction rate was found to be 29, while mean duration of generation was 29.72 days. The approximate value of natural increase r_c was 0.1133. The observed finite rate of increase (λ) showed that the population of parasitoid multiplied 1.1199 times/female/day. Taxonomic identification of the *Pachycrepoideus* sp. was done by Narendran *et al.* (1992) and named as *Pachycrepoideus veerannai*.

Investigations are in progress to study various aspects of *Pachycrepoideus veerannai* and its relation with other parasitoids of *E. sorbillans* to exploit it as a bio-control agent in checking the uzifly population.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, KSSDI, Bangalore, for facilities provided and encouragement. Thanks are also due to Dr. T. C. Narendran, Professor of Zoology, University of Calicut, India, for the identification of the parasitoid *Pachycrepoideus veerannai* Narendran & Anil.

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Fig. 1. Adult female of *Pachycrepoideus veerannai*, Narendran & Anil.

Fig. 2. Adult male of *Pachycrepoideus veerannai*, Narendran & Anil.

TABLE 1. Life Table (for females) : Age Specific Fecundity for *Pachycrepoideus veerannai.*

Pivotal age in days x	Age specific longevity l_x	Age specific fecundity m_x	$l_x\, m_x$	$x.l_x m_x$
1 - 22 days	immature stages			
23	1	0.0	0.0	0.0
24	1	0.0	0.0	0.0
25	1	1.2	1.2	30
26	1	5.2	5.2	135.2
27	1	4.2	4.2	113.4
28	1	2.6	2.6	72.8
29	1	2.2	2.2	63.8
30	1	2.2	2.2	66.0
31	1	2.0	2.0	62.0
32	1	2.2	2.2	70.4
33	1	3.4	3.4	112.2
34	1	1.0	1.0	34.0
35	1	0.8	0.8	28.0
36	1	0.6	0.6	21.6
37	1	0.6	0.6	22.2
38	1	0.8	0.8	30.4
39	1	0.0	0.0	00.00

$R_o = \Sigma\, l_x m_x = 29$ $\qquad \Sigma\, x.l_x m_x = 862$

TABLE. 2. Life Table Statistics of *Pachycrepoideus veerannai.*

Particulars	Values
R_o	29
T_c	29.72 days
r_c	0.1133
	1.1199
Average longevity	30.6
Minimum longevity	20.0
Maximum longevity	45.0
Sex ratio	3:1 (female : male)

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EFFECT OF SOLAR HEAT TREATMENT (SUNDRYING) ON THE INACTIVATION OF THE MUSCARDINE FUNGUS *BEAUVERIA BASSIANA* (BALS.) VUILL. INFECTING THE SILKWORM *BOMBYX MORI* L.

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The solar heat treatment of fungal inoculated trays for a duration of 0.5 to 5.0 days revealed that solar treatment beyond two days was effective in inactivating the white muscardine fungus as revealed by conidial survival, rearing and cocoon parameters. In general, the rearing parameters recorded in trays which received 3.0 to 5.0 days duration of solar heat treatment were found on par with that of formalin treated control.

(*Key words: Beauveria bassiana*, solar heat treatment, sunlight, larval mortality, germination, spinning percentage, pupation, cocoon weight, pupal weight, moth emergence)

INTRODUCTION

Karnataka is the major silk producing state contributing 68 per cent of the Indian silk. India ranks second in the world with regard to mulberry silk production. However, the silk yield per 100 layings is comparatively low both qualitatively and quantitatively due to the diseases of silkworm and has remained the most uncertain of all the agricultural professions (MUKERJI, 1912). To mitigate this uncertainty leading to severe losses in rearings and to enhance the prospects of sericulture, the need for studying in depth the silkworm diseases and also their control is keenly felt since the beginning of this century in India.

The influence of environment as abiotic factor on the fungal pathogen of insects is complex. The factors which govern the growth, sporulation and germination of the pathogen differ considerably in nature. In nature, the epizootics of the white muscardine disease of the silkworm have been noticed many times in the past causing considerable damage. The frequent occurrence of epizootics of the disease might be due to environmental factors. Therefore, forecasting of the pre-disposing factors and the types of measures to be taken are quite essential to prevent cocoon losses. Despite several studies made on this fungus, the information concerning the exact causes for the epizootics of the disease in nature and methods to check the spread of the inoculum are scanty, except chemical advocation of formalin chaff and dithane M-45 for the control of *Beauveria bassiana* on silkworm (NARASIMHANNA *et al.*, 1976). Hence, the present investigations were conducted with a view to assess the effect of solar heat treatment on the inactivation of the muscardine fungus.

MATERIALS AND METHODS

Well disinfected bamboo trays measuring 1.5 feet diameter were sprayed uniformly

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with spore suspension of the white muscardine fungus (10^5 spores/ml) using baby sprayer and were shade dried for 24 hours to enable adherence of the inoculum to the trays. Such trays were exposed to solar heat as per the treatment schedule (see treatment schedule). The different durations of exposures of the trays were adjusted in such a way that the trays became available for rearing simultaneously. The weather factors like maximum and minimum temperature, relative humidity and sunshine hours during the day were recorded during the period of experiment. These trays were used for rearing fifty worms of pure Mysore race which had just entered into the fifth instar following standard rearing practices (KRISHNASWAMI *et al.*, 1973) which included use of nylon mesh to prevent any parasitization by Uzifly (*Exorista sorbillans* Wiedmann). The experimental room was disinfected by 4 per cent formalin prior to starting of rearing, thereby efficiently avoiding any other pathogenic contamination.

Both in treated and untreated trays, an area of 100 sq cm was washed with 10 ml of distilled water and the washed liquid was collected in a sterilized beaker. Using a drop of this suspension, the spore count, the percentage of spore germination was estimated by spreading a drop of suspension (washings collected from the trays sprayed with fungal inoculum) on a thin layer of Sabourand's dextrose media, placed in a cavity of sterile microslide and incubated at room temperature and humidity for 48 hours after covering it with a sterile coverslip. The germination counts were taken under a research microscope. A cavity slide having three cavities was used and each cavity constituted a replication. Observations on the number of spores germinating and the non-viable one were made and the percentage of germination was calculated.

Treatment schedule

Treatments	Duration (days)	Replication
	0.5	
Solar heat treatment	1.0	
	1.5	
	2.0	Three
	3.0	
	4.0	
	5.0	
Control 1. Trays + inoculum	(without solar heat treatment)	
2. Trays + inoculum	(disinfected with two per cent formalin)	

Total number of treatments 9 (Nine)

Observations were recorded on the larval mortality due to disease, spinning percentage and cocoon characters like cocoon weight, pupal weight and moth emergence. The data was analysed statistically using two-way analysis of variance.

RESULTS AND DSCUSSION

Survival of conidia

Influence of solar heat treatment of muscardine infected trays for varied duration (0.5 to 5.0 days) was observed to be distinct in killing the conidia as revealed by their germination. The solar heat treatment was able to significantly reduce the conidial germination compared to control (90.90 per cent). Amongst the treatments, highest conidial germination was recorded at 0.5 days (76.26 per cent) followed by 1.0 (33.34 per cent), 1.5 (27.10 per cent), 2.0 (14.93 per cent) and 3.0 (3.76 per cent) days durations of solar heat treatment and they differed significantly establishing a direct

relationship between them. However, total inactivation of fungus was registered with 4.0 and 5.0 days duration of solar heat treatment (Table 1; Fig. 1). Information on other fungi are in agreement with the present findings. MADDISON & MANNERS (1972), and DILAIMYI (1976) have reported the inhibitory action of sunlight on *Puccinia graminispers* and *Trichophyton rubrum* [cast] Sabour respectively. BYRA-REDDY (1986) brought out the inhibitory action of solar heat treatment on *Beauveria bassiana*, wherein he concluded that when the muscardine inoculated trays were disinfected using solar radiation, the larval, pupal and total mortality were found to reduce to 8.5, 6.0 and 14.5 per cent as against 72.0, 11.5 and 83.5 per cent mortality of the same stages when rearing was conducted in the infected trays.

TABLE 1. Germination percentage of conidia of *Beauveria bassiana* (Bals.) Vuill after exposure to varied duration of sunlight (Solar heat treatment).

Duration of exposure to sunlight (days)	Germination (%)	Transformed values $\sqrt{(x + 0.5)}$
0.00	90.90	9.56
0.50	76.26	8.76
1.00	33.34	5.82
1.50	27.10	5.25
2.00	14.93	3.93
3.00	3.76	2.06
4.00	0.00	0.70
5.00	0.00	0.70
Formalin control	0.00	0.70
C.D. at 5%		1.29

Larval mortality

The larval mortality of silkworms differed significantly due to differential durations of solar heat treatment of muscardine inoculated trays compared to control (45.30 per cent). It ranged from 0.00 to 20.00 per cent in solar heat treatment duration range of 0.5 to 5.0 days establishing a clear inverse relationship (Table 2; Fig. 2).

The larval mortality was significantly higher in 0.5 to 1.5 days durations (20.00 to 17.33 per cent) compared to 2.0 to 5.0 days duration, wherein, mortality was noticed to be 0.00 to 2.67 per cent signifying the importance of these durations for freeing fungal infections from the trays. Similarly, BYRA-REDDY (1986) was able to reduce larval mortality to 8.5 per cent with solar treatment compared to control (72.00 per cent) wherein, the trays were artificially contaminated with fungal inoculum and were not disinfected, which is comparable to the present observations.

Spinning percentage

Solar heat treatment of varied durations of fungus inoculated trays significantly influenced the survival of spores which in turn the rearing parameter: spinning percentage. In all the treatments, spinning percentage increased significantly compared to control (54.60 per cent). At 0.5 to 1.5 days duration the spinning was significantly reduced (82.66 to 80.00 per cent), compared to 2.0 to 5.0 days duration of solar heat treatment, wherein 97.33 per cent spinning was noticed evidencing almost cent per cent inactivation of fungal inoculum inoculated on trays (Table 2; Fig. 2). The findings are in accordance with those of BYRA-REDDY (1986) who reported lesser larval mortality leading to higher spinning when rearing was done in trays exposed to sunlight after infection compared to control. The lesser

spinning in lower duration treatment was due to incomplete inactivation of fungus and continuance of disease which is in conformity with KRISHNASWAMI *et al.* (1973) who reported the death of some diseased larvae either in larval stage or during the cocoon construction resulting in lesser spinning of larvae.

Pupation

The pupation differed significantly due to differential duration of solar heat treatment of muscardine inoculated trays compared to control, wherein no pupation occurred. The pupation ranged from 62.67 to 100.00 per cent in solar heat treatment duration range of 0.5 to 5.0 days indicating a direct relationship. The pupation was significantly lower in 0.5 to 2.0 days duration (62.67 to 76.67 per cent) compared to 3.0 to 5.0 days duration wherein 99.00 to 100.00 per cent pupation was observed signifying the importance of these durations for freeing the fungal infection from trays creating a sanitary condition for the purpose of silkworm rearing (Table 2; Fig. 2). Similarly, BYRA-REDDY (1986) reported lesser pupal mortality due to

TABLE 2. Effect of solar heat treatment on inactivation of the conidia of the fungus *Beauveria bassiana* (Bals) Vuill. as revealed by rearing and cocoon parameters in 'Pure Mysore' race.

Duration of exposure to sunlight (Days)	Larval mortality (%)	Spinning (%)	pupation (%)	Single cocoon weight (g)	Single pupal weight (g)	Moth emergence (%)
0.00	45.33 (6.79)	54.60	0.00 (0.70)	0.75	0.00 (0.70)	0.00 (0.70)
0.50	20.00 (4.53)	80.00	62.67 (7.95)	1.06	0.96 (1.21)	62.67 (7.93)
1.00	20.00 (4.53)	80.00	70.00 (8.40)	1.29	0.97 (1.21)	70.00 (8.40)
1.50	17.33 (4.22)	82.66	76.67 (8.78)	1.32	1.02 (1.23)	76.67 (8.78)
2.00	2.67 (1.78)	97.33	76.67 (8.78)	1.33	1.03 (1.23)	76.67 (8.78)
3.00	1.00 (1.22)	99.00	99.00 (9.97)	1.36	1.03 (1.23)	99.00 (9.97)
4.00	0.00 (0.70)	100.00	100.00 (10.02)	1.36	1.08 (1.25)	100.00 (10.02)
5.00	0.00 (0.70)	100.00	100.00 (10.02)	1.38	1.09 (1.25)	100.00 (10.02)
Formalin control	0.00 (0.70	100.00	100.00 (10.02)	1.46	1.12 (1.27)	100.00 (10.02)
C.D. at 5 %	1.77	13.22	1.01	0.16	0.04	1.01

( ) = /x + 0.5 transformed values.

sunlight inactivation of fungal inoculum leading to higher pupation.

Cocoon weight

The influence of solar heat treatment was significant in improving the cocoon weight compared to control (0.75 g). The cocoon weight recorded above 1.0 days duration were found on par with that of formalin control (1.46 g). In the rest of the treatments, the cocoon weight recorded did differ significantly. It was found highest at 5.0 days (1.38 g) followed by 4.0 and 3.0 days (1.36 g) durations of treatments, signifying the influence of these durations in inactivating the fungal inoculum (Table 2; Fig. 2). The findings are in accordance with those of BYRA-REDDY (1986) who reported on par cocoon weight with the sunlight treatment (1.852 g) and formalin treated control (1.852 g).

Pupal weight

Solar heat treatment of fungal inoculated trays significantly influenced the pupal weight of the worms reared in them. Amongst the treatments, the pupal weight did not vary significantly with the worms which were reared in the inoculated trays exposed to different days of treatment. It ranged from 0.96 to 1.09 g and were inferior to formalin treated control (1.12 g) illustrating the biassed scope of solar heat treatment inactivating the fugal inoculum. The non-pupation and lesser pupal weight in some of the treatments was due to disease residues in the individuals. (Table 2; Fig. 2). The present findings are comparable with those of ARBOUSSET (1993) and KRISHNASWAMI *et al.* (1973) who reported decreased cocoon/pupal weight due to muscardine infection. VENKATARAMANA-REDDY (1978) also opined similarly, recording decreased pupal weight due to devitalisation of pupae on account of muscardine infection. However, BYRA-REDDY (1986) recorded on par pupal weight with sunlight treatment (1.497 g) and control formalin treated trays (1.395 g).

Moth emergence

The influence of solar heat treatment of inoculated trays was significant in altering the moth emergence. It was in direct relationship with increased solar heat treatment. Although 54.60 per cent of spinning was noticed in worms which were reared in trays inoculated with fungus, but not exposed to solar treatment, no pupation was observed consequently leading to non-emergence of moths. Moth emergence of 62.67 to 76.67 per cent was observed in treatment of 0.5 to 2.0 days of solar heat treatment which indicated the inactivation of fungal inoculum. Cent per cent moth emergence was observed in case of further increase of solar heat treatment for 3.0 to 5.0 days duration which was on par with emergence observed in formalin treated control. This revealed that the 3.0 to 5.0 days duration of solar heat treatment was optimal for fungal inactivation and promotion of better rearing practices resulting in good moth emergence (Table 2) (Fig. 2). The lesser emergence observed a lower durations was due to incomplete inactivation of fungs and continuance of disease. Similar findings were observed by ARBOUSSET (1893), MUKERJI (1912), KRISHNASWAMI *et al.* (1973) and VENKATARAMANA - REDDY (1978) who reported the lightness of muscardined cocoons, the inside pupae being dead leading to non-emergence.

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DESCRIPTION OF *SCAPHODHARA* A NEW GENUS RELATED TO *SCAPHOIDEUS* (HOMOPTERA: CICADELLIDAE) AND FIVE NEW SPECIES FROM SOUTH INDIA

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A new genus *Scaphodharc* (type species, *Scaphodhara sahyadrica* n. sp.) is described. It is related to *Scaphoideus* Uhler but differs in not having paraphysis to the connective and in possessing an intermediate sclerite between aedeagus and connective. Five new species namely, *Scaphodhara biloba* n. sp. (from Karnataka: Belgaum, Dharwar), *S. sahyadrica* n. sp. (from Karnataka: Mndigere, Kerala: Calicut, Meppadi, Thekkadi), *S. periyari* n. sp. (from Kerala: Thekkadi), *S. raoi* n. sp. (from Karnataka: Dharwar, Tamil Nadu: Nilgiris) and *S. neela* n. sp. (from Kerala: Munnar, Thekkadi) are described and illustrated. Their relation with each other and with some species of *Scaphoideus* is also discussed. A key to the included species is also given.

(*Key words: Scaphodhara, Scaphoideus*, Leafhoppers, new genus, new species)

During a revisionary study of the genus *Scaphoideus* Uhler in the Indian subcontinent, a few specimens which apparently looked like the species complex of *Scaphoiideus albovittata* Matsumura, *S. hirlani* Kitbamroong and Freytag, *Scaphoideus knapii* Kitbamroong and Freytag (Kitbamroong and Freytag, 1978) and *Scaphoideus insignis* (Distant) (Distant, 1918) were collected along the Western Ghats in the States of Karnataka, Kerala and Tamil Nadu. On a closer examination they were found to form a natural group distinct from *Scaphoideus* and are here described as the new genus *Scaphodhara*.

The holotypes of the new taxa described here are deposited in the Department of Entomology, University of Agricultural Sciences, Bangalore (UAS). The paratypes will be deposited in the National Pusa Collection, Indian Agricultural Research Institute, New Delhi (IARI), The Natural History Museum, London (NHM) and the U.S. National Museum of Natural History, Washington, D.C. (USNM) as indicated under each species.

Scaphodhara n. gen.

Type species: *Scaphodhara sahyadrica* n. sp.

Colouration similar to some species of *Scaphoideus* namely *S. insignis*, *S. albovittatus*, *S. hirlani*, and *S. knapii*. Head, pronotum, scutellum and folded forewings traversed by a broad median ivory or yellowish white stripe flanked by lateral brown fascia.

Head including eyes narrower than pronotum. Head bluntly conically pointed anteriorly. Vertex longer than interocular distance. Face longer than wide, ratio between width of frontoclypeus at apex to that between bases of antennae varies from 1:1.48 to 1.68. Pronotum 0.46 times as long as wide, usually shorter than scutellum. Forewing similar to that in

Scaphoideus. Fore femora without short stout setae but with 9 to 11 hair-like setae on meso-apical area, middle femora with short stout setae of uniform length.

Male pygofer longer than its height, with a ventrally directed process on dorsal margin caudally rounded or bluntly pointed lobe with tufts of long and scattered setae. Subgenital plate triangular, attenuated caudally and some times bifid. Style with well developed preapical lobe, apophysis short, curved laterally, apex either sharply or bluntly pointed, its body often rugose. Connective Y-shaped in anterior part, an intermediate, unpigmented, sclerite often present between aedeagus and connective with which it is either articulated or fused. Aedeagus often compressed and with a pair of apical processes. Gonopore apical. Ovipositor extending beyond pygofer.

Remarks: Scaphodhara and *Scaphoideus* are very closely related. Some species of both the genera have identical colouration and hence are difficult to separate without recourse to the examination of male genitalia. The accompanying table of characters help of separate the genera.

KEY TO THE SPECIES OF *SCAPHODHARA*

1. Male subgential plate bilobed (Fig. 5); aedeagal shaft strongly curved appearing C-shaped (Fig. 9); apophysis of style stout, with rounded apex (Fig. 6) (Karnataka: Belgaum. Dharwar). .... *S. biloba* n. sp.

— Male subgenital plate not bilobed; aedeagal shaft straight, apophysis of style slender, curved laterally with an acute apex 2

2. Aedeagal shaft compressed, processes at least half as long as shaft, strongly recurved antero-ventrally (Figs. 21, 32, 42) 3

— Aedeagal shaft not strongly compressed, processes short, less than 0.25 as long as shaft, anteriorly directed (Fig. 50) (Kerala: Munnar, Thekkadi) .... *S. neela* n. sp.

3. Preatrium of aedeagus very well developed, prolonged, about 0.75 as long as shaft (Fig. 42)

Character	*Scaphodhara*	*Scaphoideus*
Ratio between width and length of vertex	1 : 1.19 to 1.4	1 : 1.02
Ratio of width of frontoclypeus at apex to that between antennal bases	1 : 1.48 to 1.08	1 : 1.68 to 1.32
Paraphysis	Absent	Present
Intermediate unpigmented sclerite between aedeagus and connective	Present except in *S. biloba* n. sp.	Absent
Aedeagus	Fairly large, with a pair of apical or subapical processes.	Fairly small, often very small, with or without apical processes.
Colouration	A median ivory or yellow stripe traversing head, pronotum, scutellum and folded forewings.	Variable, a few species with similar colouration.

(Karnataka: Dharwar, Tamil Nadu: Nilgiris .... *S. raoi* n. sp.

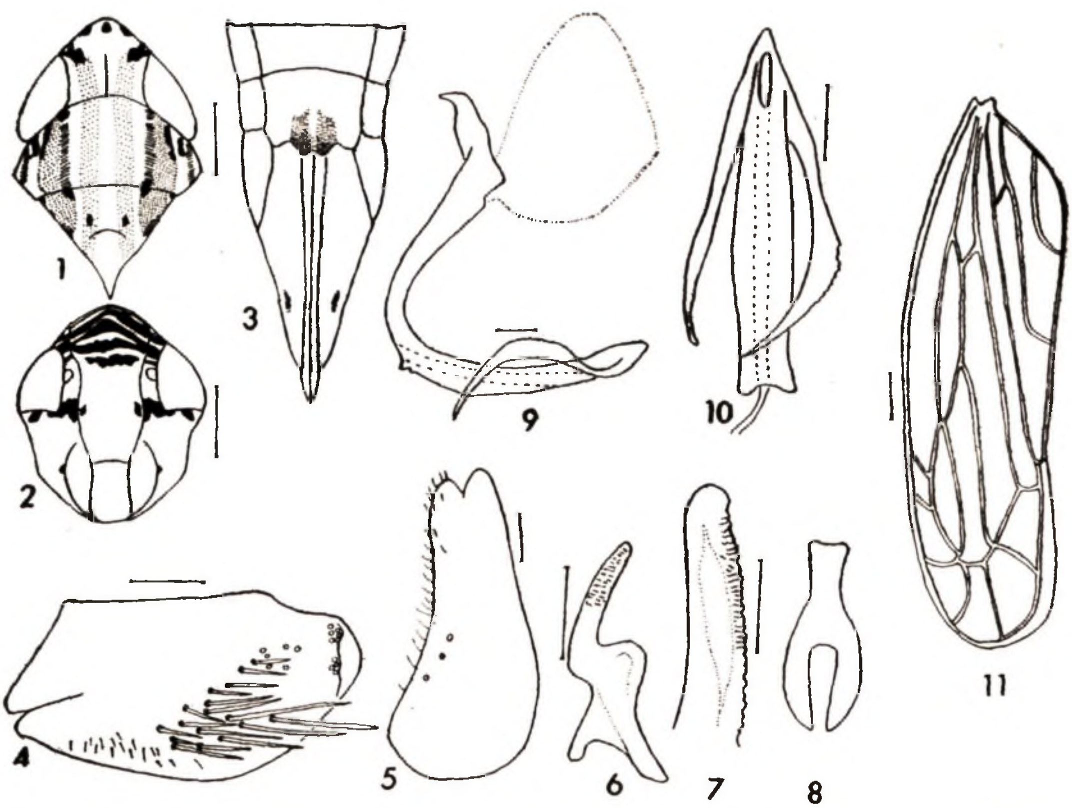
Preatrium of aedeagus short, less than 0.5 as long as shaft. 4

4. Aedeagal shaft longer, 0.26 as wide as long in lateral aspect (Fig. 21); caudal lobe of pygofer rounded (Fig. 16); only one reflexed vein joining outer anteapical cell (Fig. 15) (Karnataka: Mudigere, Jog Falls, Kerala: Calicut, Meppadi, Thekkadi) .... *S. sahyadrica* n. this.

Aedeagal shaft shorter, 0.4 as wide as long in lateral aspect (Fig. 32); caudal lobe of pygofer acutely angled (Fig. 28); both reflexed veins joining outer anteapical cell (Fig. 27) (Kerala: Thekkadi) .... *S. periyari* n. sp.

1. **Scaphodhara biloba** n. sp. (Figs. 1-11)

A narrow orange stripe on vertex, pronotum and scutellum on median ivory stripe on either side of median line. A spot at apex of vertex, two adjacent slightly transverse spots to it partially visible from above, an oblique spot arising from each ocellus, anterior margin of eyes, dark chocolate brown. Face ochraceous, area above a line across antennal base with two complete and two to three incomplete transverse dark chocolate brown fasciae; a transverse brown fascia across lower angle of compound eyes. A spot on gena adjacent to lorum light brown. Lateral aspect



Figs. 1-11. *Scaphodhara biloba* n. sp. 1. Head and thorax; 2. Face; 3. Ovipositor; 4. Pygofer, long setae not shown; 5. Subgenital plate; 6. Style; 7. Apohysis of style; 8. Connective; 9. Aedeagus, lateral aspect; 10. Aedeagal shaft, dorsal aspect; 11. Forewing. Scale refers to 0.5 mm for Figs 1, 2, 3 and 11, and 0.1 mm for Figs. 4 to 10.

of pronotum with two long brown stripes, extreme lateral margin and area between the brown stripes ochraceous. Basal angles of scutellum brown. Ventral spot on epimeron and a large spot on mesepisternum brown. Anterior area of fore wing hyaline, venation brown, a spot on cross vein between outer and median apical cell, medial area, median anteapical cell longitudinally dark brown. Legs ochraceous, hind tibiae spotted with brown at bases of spines and at apex.

Vertex depressed medially, slightly broader between eyes than its median length, anteriorly acutely angled, coronal sulcus reaching 0.75 of length. Vertex, pronotum and scutellum polished. Claval veins connected by a cross vein, outer claval vein connected with claval suture. Outer anteapical cell 0.75 as long as median anteapical cell, two reflexed veins connect outer anteapical cell with costal margin.

Male genitalia: Pygofer with caudodorsal area rounded, with submarginal tufts of long setae in addition to scattered setae on ventral half. Subgenital plate with bilobed apex. Style stout, short, apophysis well developed, pustulated, half as long as total length of style. Connective Y-shaped, with well developed dorsal apodeme, as long as shaft, aedeagal shaft directed caudally, of uniform width in lateral aspect, with a pair of antero-ventrally curved subapical processes. Gonopore elongate, on ventral margin.

Female genitalia: Seventh sternum slightly longer than sixth, its caudal margin medially produced into a bilobed rather W-shaped process.

Measurements: Male 5.7 to 6.5 mm long, head 1.3 to 1.42 mm across eyes, pronotum 1.4 to 1.58 mm wide. Female 6.8 mm long, head 1.5 mm wide across eyes, pronotum 1.65 mm wide.

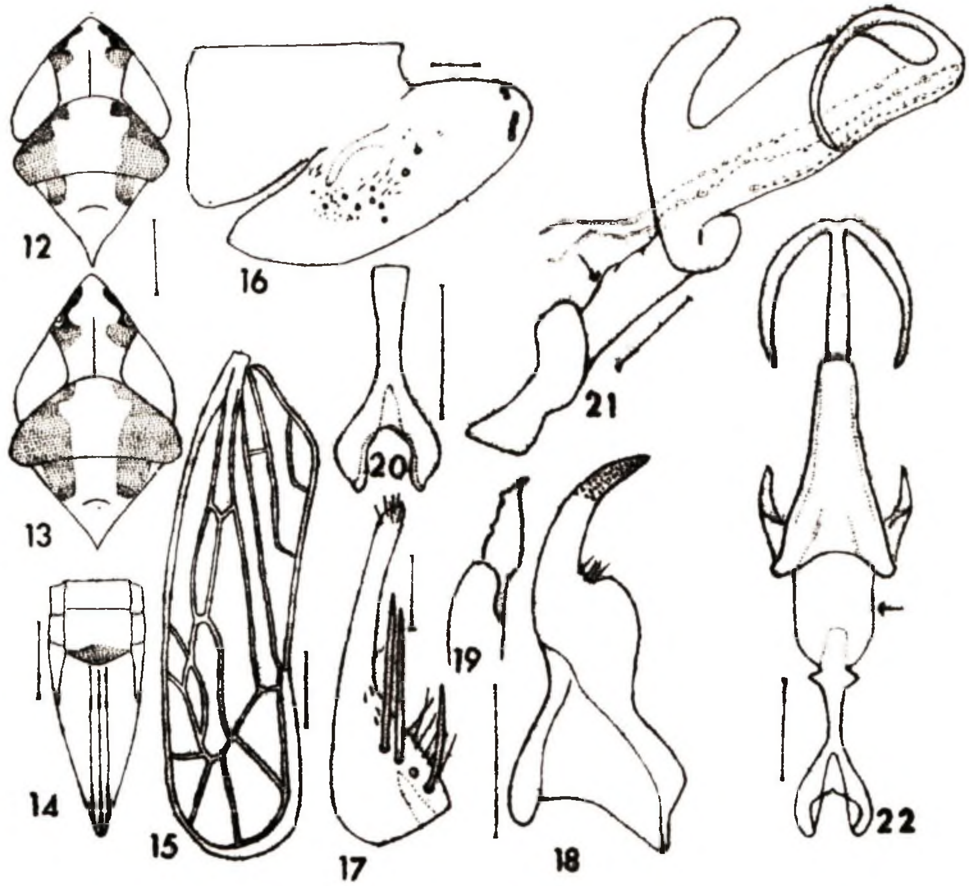
Material examined: Holotype ♂, INDIA, Karnataka: Ag. Coll. Dharwar, 10. viii. 1972, C.A. Virakatamath (UAS). Paratypes 2 ♂, 2 ♀, INDIA: Karnataka: Belgaum, 30.vii.1973, C.A. Viraktamath; 1 ♂, INDIA : Karnataka: 19 km W of Dharwar, 12.xi.1991, C. A. Viraktamath (IARI, NHM, UAS, USNM).

Remarks: Externally this species resembles *Scaphoideus insignis* (Distant) but differs in lacking the paraphysis and also in the structure of male genitalia. It is unique among *Scaphodhara* in having bilobed apex of subgenital plate and slender, strongly recurved aedeagal shaft.

2. **Scaphodhara sahyadrica** n. sp. (Figs. 12–22).

Vertex, median stripe on pronotum and scutellum creamy white; an oblique spot on either side of median line near apex of vertex on anterior margin fuscous; an irregular spot behind each ocellus reddish brown with anterior and lateral fuscous markings. Face above with four transverse bands and a transverse spot below each atennal base piceous. Lateral area of pronotum yellowish brown with darker inner margin. Basal triangles of scutellum fuscous with inner darker margin, an oblique fascia on proepisternum, meso and meta thoracic pleura fuscous. Clavus with hyaline inner margin, claval cell between veins brownish with a median dark brown patch, corium with a brown patch on inner anteapical cell, third apical cell, costal area at basal 0.33, oblique fascia to costa dark brown, venation brown. Three spots on middle tibia, first and second tarsomeres of middle leg, bases of hind tibial spines on outer margin, apex of first tarsomere and second tarsomere except apex piceous.

Head bluntly conically pointed; narrower than pronotum, vertex medially 1.6 times



Figs. 12–22. *Scaphodhara sahyadrica* n. sp. 12. Head and thorax, male; 13. Same, female; 14. Ovipositor; 15. Forewing; 16. Male pygofer; 17. Subgenital plate; 18. Style; 19. Apex of style lateral view; 20. Connective; 21. Connective, intermediate sclerite (arrowed) and aedeagus in lateral aspect; 22. Same, dorsal aspect. Scale refers to 0.5 mm for Figs. 12–15 and 0.1 mm for Figs. 16 to 22.

longer than interocular distance. Outer apical cell 0.5 as long as inner one. Two or three reflexed veins between costa and outer anteapical cell.

Male genitalia: Pygofer elongate, with two tufts of subapical setae, caudal margin rounded, pygofer process simple. Subgenetal plate with apical 0.66 part narrowed, basal 0.33 braod, with four long setae arranged in an oblique row. Apophysis of style 0.33 as long as length of style, with a subapical tooth and serrated ventral margin. Connective fused with intermediate sclerite, stem of Y longer than arm, aedeagus with well devloped slightly arcuate dorsal apodeme, shaft directed caudally, strongly compressed, with an apical pair of arcuate processes directed anteriorly and ventrally. Gonopore apical.

Female genitalia : Hind margin of seventh sternum medially slightly conically produced, twice as long as median length of sixth sternum.

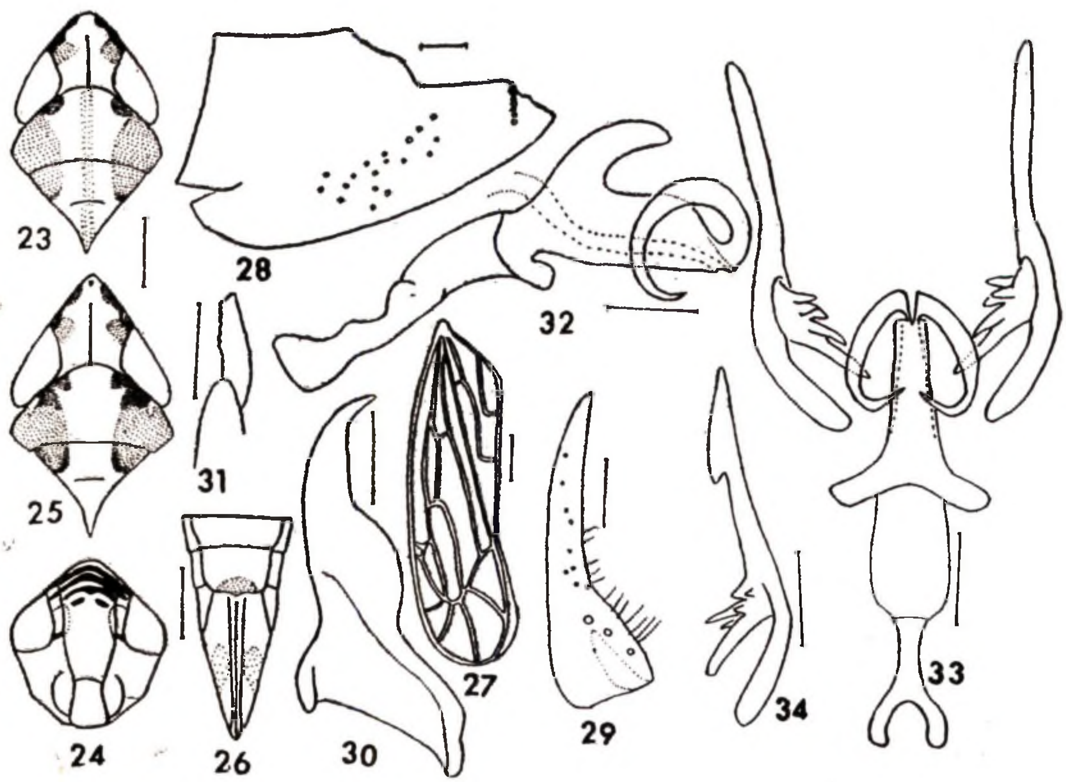
Measurements: Male 4.2 to 4.5 mm long, head 0.88 to 1.0 mm wide across eyes, pronotum 0.98 to 1.05 mm wide. Female 4.7 to 5.3 mm long, head 1.05 to 1.17 mm wide across eyes, pronotum 1.1 to 1.27 mm wide.

Material examined: Holotype ♂, INDIA: Kerala: Meppadi, 690 m, 17–18.x.1975, Ghorpade Coll. No. A244 (UAS). Paratypes: 1 ♂, data as for holotype; 2♂, 9♀, India: Karnataka; Mudigere, 970 m, collected on 8.iv.1975 (2 ♀), 1.vi.1978 (1 ♀), 2.vi.1978 (1 ♀), 4.vi.1978 (1 ♀), 7.iv.1980 (1 ♀) by C.A. Viraktamath; on 2.vi.1978 (1♀) by H.S. Krishnamurthy; on 24.vi. 1989 (1 ♂, 4 ♀) by V.V. Belavadi; Kerala: 1 ♂, 1 ♀, Thekkadi, 884 m, 26.iii.1977, C. A. Viraktamath and on 27.iii.1977, B. Mallik (IARI, NHM, UAS, USNM).

Remarks: S. sahyadrica is closely related to *S. raoi* n. sp. and *S. periyari* n. sp. They have similar male genitalia. *S. sahyadrica* can however be differentiated from both of them by the absence of median orange coloured fascia on vertex and thorax, simple pygofer process and by the shorter process of the aedeagal shaft.

3. **Scaphodhara periyari** n. sp. (Figs. 23-34)

Colouration as in *S. sahyadrica* with following differences. Spots behind ocelli



Figs. 23–34. *Scaphodhara periyari* n. sp. 23. Head and thorax, male; 24. Face, male; 25. Head and thorax, female; 26. Ovipositor; 27. Forewing; 28. Male pygofers only setal bases shown; 29. Subgenital plate; 30. Style, 31. Apex of style; 32. Connective, intermediate sclerite and aedeagus, lateral view; 33. Same, and pygofer process, ventrocadual view; 34. Pygofer process, lateral view Scale refers to 0.5 mm for Figs. 23 to 34 and 0.1 mm for Figs 28 to 34.

on vertex reddish. Lateral area of pronotum more uniformly brownish. Median sulcus and median line traversing length of prontoum and scutellum orange.

Vertex medially 1.4 times as long as interocular distance. Pronotum slightly wider than head, more than twice as wide as long. Outer anteapical cell about 0.5 times as long as median anteapical cell.

Male genitalia: Pygofer with its caudal margin bluntly conical, submarginal tufts of long setae, dorsal pygofer process well developed with two to five finger-like processess distally. Subgenital plates 0.5 times as long as pygofer, elongate, broad at basal 0.33, narrowed to apex, with three long setae, in an oblique row. Apophysis of style laterally curved, ventral margin serrate. Connective with stem of Y twice as long as arm, fused with intermediate sclerite. Aedeagus strongly compressed, with a pair of strongly recurved long apical processes, dorsal apodeme well developed.

Female genitalia: Seventh sternum twice as long as sixth, caudal margin narrowly piceous in the middle and rather straight with a median slight excavation.

Measurements: Male 4.6 to 4.7 mm long, head 0.97 mm to 1.0 mm wide across eyes, pronotum 1.05 to 1.07 mm wide. Female 5.0 mm long, head 1.07 mm wide across eyes, pronotum 1.15 mm wide.

Material examined: Holotype ♂, INDIA: Kerala: Thekkadi, 884 m, 27.iii.1977, C. A. Virakatmath (UAS). Paratypes: 3 ♂, data as for holotype but 1 ♂ collected by B. Mallik, 1 ♂ on 26.iii.1977 by S. Viraktamath; 1 ♀ Kerala; Maraiyur, 1066 m, 24.iii.1977, B. Mallik (IARI, UAS).

Remarks: This species can easily be recognised by the median orange line on mid dorsal line on head, pronotum and scultellum in which it resembles *S. neela* sp. n. but it lacks the tiny black spot at apex of vertex. It differs from *S. neela* in having aedeagus of the type found in *sahyadrica* and *raoi* but shorter and stouter.

4. **Scaphodhara raoi** n. sp. (Figs. 35–43).

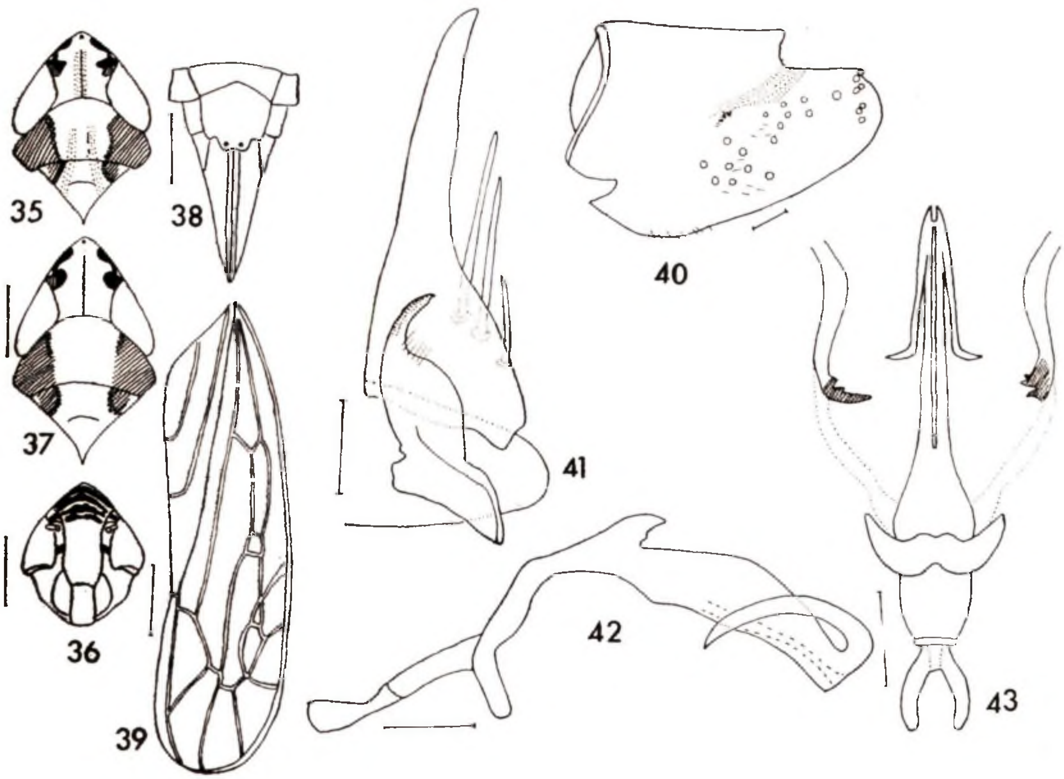
Colouration similar to that in *S. sahyadrica* but all brown markings darker, appearing chocolate brown to black in males. A median apical small spot at apex of vertex blackish. A medain faint narrow stripe on vertex and a line either side of median line on pronotum and scutellum yellowish, more pronounced in males.

Head bluntly produced in front. Vertex 1.33 (♂) to 1.5 (♀) as long as interocular distance. Pronotum as long as or shorter than scutellum. Two (in paratypes) to three reflexed veins reaching outer anteapical cell from costa, outer anteapical cell often subdivided (in paratypes).

Male genitalia: Pygofer elongate, with an asymmetrically forked dorsal process. Subgenital plate triangular, caudally narrowed at basal 0.33 bearing 3 long setae. Style short, stout, apophysis short, laterally curved with a pointed apex. Connective short, stem of Y 0.5 times as long as arm. Aedeagus with anteriorly prolonged, forked preatrium, dorsal apodeme short, shaft compressed, directed caudally, with a pair of strongly recurved apical processes arising on dorsal angle of shaft.

Female genitalia: Seventh sternum twice as long as sixth, caudal margin medially broadly produced with a median notch.

Measurements: Male 4.2 to 4.3 mm long, head 1.0 mm wide across eyes, pronotum 1.0 mm wide. Female 4.5 mm long, head 1.05 mm wide across eyes, pronotum 1.05 mm wide.



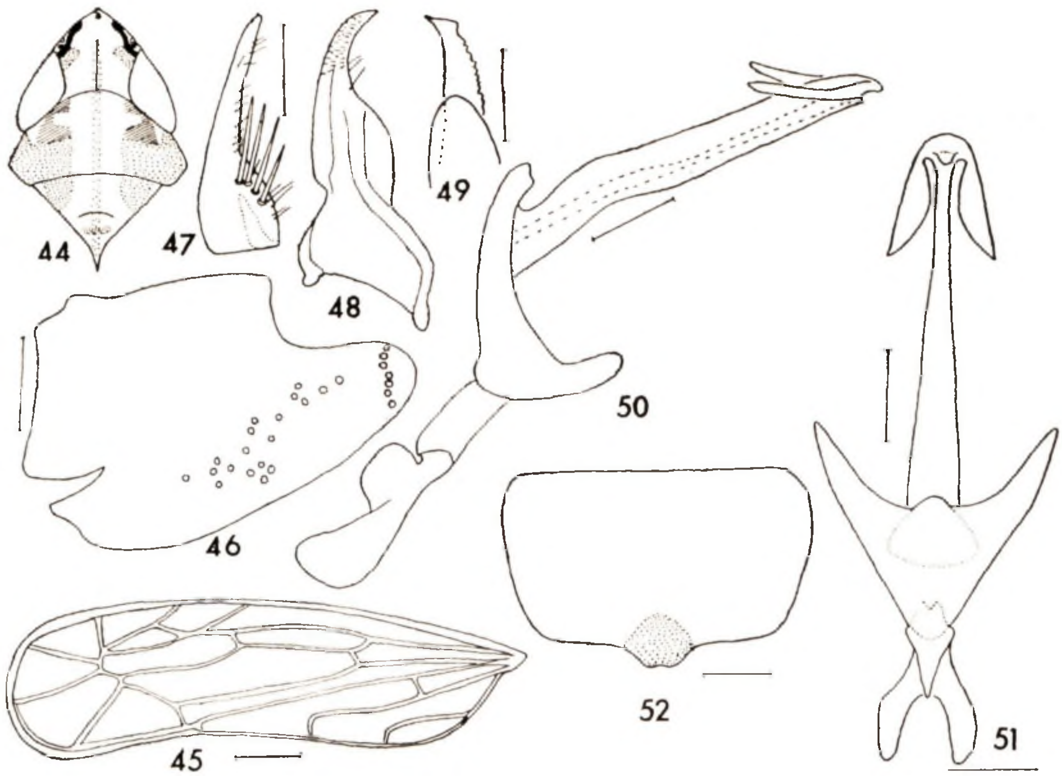
Figs. 35–43. *Scaphodhara raoi* n. sp. 35. Head and thorax, male; 36. Face, male; 37. Head and thorax, female; 38. Ovipositor; 39. Forewig; 40. Male pygofer, only setal bases shown; 41. Connective, intermediate sclerite, aedeagus, lateral view; 43. Same and pygofer process, ventral view. Scale refers to 0.5 mm for Figs. 35 to 39 and 0.1 mm for Figs. 40 to 43.

Material examined: Holotype ♂, INDIA: Karnataka: 19 km W of Dharwar, 12.xi. 1991, C. A. Viraktamath (UAS). Paratypes: 1 ♀, data as for holotype; 1 ♂ INDIA: Tamil Nadu : Madumalai: Dodagatti, 1080 m, 24.xii.1991, Thyagaraja, (IARI, NHM).

Remarks: This species differs from *S. sahyadrica* and *S. periyari* to which it is closely related in having very much elongated preatrium. It is named in honour of Dr. K.R. Rao, Zoological Survey of India, Madras.

5. **Scaphodhara neela** n. sp. (Figs. 44–52).

Colouration as in *S. sahyadrica* with following differences. A median reddish orange line traversing from basal 0.66 on vertex to apex of scutellum, apex of vertex with a minute fuscous spot; sinuate line on lateral margin widened as a pot at its apex on vertex, fuscous; a large round reddish brown spot confluent with posterior widened spot of this line. Face with three arcuate bands above bases of antennae dark fuscous, lateralmost margin ochraceous; scutellum with basal fuscous triangles.



Figs. 44–52. *Scaphodhara neela* n. sp. 44. Head and thorax, male; 45. Forewing; 46. Male pygogfer only setal bases shown; 47. Subgenital plate; 48. Style; 49. Style apex, lateral aspect; 50. Connective, intermediate sclerite and aedeagus, lateral view; 51. Same, ventral view; 52. Female seventh sternum. Scale refers to 0.5 mm for Figs. 44. 45 and 52 and 0.1 mm for Fgs. 46–51.

Head acute angled, narrower than pronotum. Vertex 1.4 times as long as interocular distance. Outer anteapical cell 0.33 as long as median anteapical cell.

Male genitalia: Pygofer with a simple dorsal process, caudally rounded. Subgenital plates as in *S. sahyadrica*. Apophysis of style rather foot-shaped apically, its surface with short discontinuous, transverse rugae. Connective with stem as long as arm, fused with intermediate sclerite. Intermediate sclerite broadened caudally, fused with aedeagus. Aedeagal shaft elongate, more or less of uniform width in lateral aspect, slightly sinuate, with a pair of short, ventrally directed apical processes.

Female genitalia: Seventh sternum twice as long as sixth, caudal margin broadly produced in the middle.

Measurements: Male 5.8 mm long, head 1.17 mm wide across eyes, pronotum 1.3 mm wide. Female 5.9 mm long, head 1.1 mm wide across eyes, pronotum 1.18 mm wide.

Material examined: Holotype ♂, INDIA Kerala: 12.5 km N. Munnar, 1972 m, 23.iii.1977, C. A. Viraktamath (UAS). Paratypes : 1♂, data as for holotype; 1 ♀, Kerala, Thekkadi, 884 m, 27.iii.1977, C.A. Virakatamath (IARI, UAS).

Remarks: *S. neela* is uniqe among the species of *Scaphodhara* in having elongate aedeagal shaft with shorter processes.

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THREE NEW SPECIES OF *IDIOCERUS* (HEMIPTERA: CICADELLIDAE) FROM NORTH INDIA

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***Idiocerus* Lewis, a predominantly holarctic idiocerine genus has been recorded for the first time from north India. Three new species namely, *Idiocerus sharmai* sp. nov. (from Sundarnagar on *Salix* sp.), *Idiocerus cedarae* sp. nov. and *Idiocerus deodarae* sp. nov. (both from Kufri, Simla on *Cedrus deodara*) are described and illustrated. A key to these three species is also given.**

(*Key words: Idiocerus*, Idiocerinae, leafhoppers, new species)

During a survey for collection of leafhoppers in north India, we discovered three species of idiocerine leafhoppers from Himachal Pradesh feeding on trees of the genera *Salix* and *Cedrus*. These were later recognised as new species of the genus *Idiocerus* Lewis and are described here. We also have in our collection two other species of the genus from Jammu and Kashmir represented by female specimens and hence have not been included in this paper.

From the time Lewis (1834) described the genus *Idiocerus* (type species *Idiocerus stigmaticalis* Lewis), thirteen species of idiocerine leafhoppers have been described in the genus from the Indian subcontinent by Lethierry (1889), Melichar (1903), Distant (1908, 1912), Baker (1924) and Pruthi (1930, 1936). However, These species have now been transferred to genera other than *Idiocerus* namely, *Amritodus* Anufriev, *Balocha* Distant, *Idioscopus* Baker and *Pedioscopus* Kirkaldy, suggesting that no true *Idiocerus* has been recorded from the Indian subcontinent (including Pakistan, India, Sri Lanka, Nepal, Bengla Desh, Bhutan and Burma). Therefore, this forms the first authentic record of the genus from the subcontinent.

Most commonly found indiocerine genus on the subcontinent is *Idioscopus*, the species of which breed on plants of the family Anacardiaceae and a few species are serious pests of mango, *Mangifera indica* L. (Viraktamath, 1989). The genus *Idiocerus* can be distinguished from *Idioscopus* as follows.

1. Hind femora with two apical spines; face flat .... *Idiocerus*

— Hind femora with two apical and one subapical spines; face convex .... *Idioscopus*

The Indian species of *Idiocerus* are characterised as follows. Head short, wider than pronotum. Eyes prominent, protruding. Vertex 6 to 8 times as wide between eyes as median length, shorter medially than adjacent to eye; transversely finely rugulose. Face flat, shorter than width including eyes, antennal pits shallow, area dorsad of ocelli finely, arcuately, rugulose. Ocelli closer to adjacent eye than to median line. Clypellus narrowed in middle, 1.5

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times as long as its width at base, medially constricted, rather as broad at base as at apex, extending beyond genal curve. Male antenna with expanded flagellar disc. Labium similar in both sexes, reaching anterior margin of hind coxae. Pronotum shagreened, 2 to 2.5 times as wide as median length, shorter than scutellum. Fore wing with 4 apical and three anteapical cells; inner anteapical cell longest, closed behind, outer anteapcal cell smallest. Hind tibial spinulation R_1 18$\pm$2, R_2 7$\pm$1, R_3 8$\pm$1. Hind basitarsus with two patellae on apical transverse row of setae. Both tergal and sternal apodemes at base of male abdomen well developed. Male pygofer dorsally incised on anterior half unarmed. Anal collar well developed. Dorsal apodeme and preatrium of aedeagus well developed, shaft tapered caudally. Female second pair of valvulae with teeth confined to 0.25 length.

KEY TO INDIAN SPECIES OF *IDIOCERUS*

1. Pronotum with numerous balck spots on anterior half, triangular spots on scutellum with apical mesal extension (Fig. 22); hind margin of female seventh sternum rather hemispherical (Fig. 30); teeth on second pair of valvula widely spaced, with not more than 15 teeth (Fig. 32) .... *I. deodarae* sp. nov.

— Pronotum with at most 4 black spots; triangular spots on scutellum without a mesal extension (Fig. 1); hind margin of female seventh sternum sinuate or medially produced (Figs. 10, 19); teeth on second pair of valvula closely spaced, with more than 16 teeth (Figs 11, 20) 2

2. Male tergal apodeme at base of abdomen well developed exceeding third tergum, as long as broad (Fig. 21); dorsal apodeme of aedeagus stout, darkly pigmented (Figs. 16, 17, 18); hind margin of female seventh sternum convex with median excavation (Fig. 19). on *Cedrus deodara* .... *I. cedarae* sp. nov.

— Male tergal apodeme at base of abdomen broad, twice as broad as long, not reaching hind margin of third tergum (Fig. 12); dorsal apodeme of aedeagus slender, less pigmeted (Fig. 7); female seventh sternum medially produced and bilobed (Figs. 9, 10) on *Salix* sp......*I. sharmai* sp. nov.

The types of the new taxa are deposited in the University of Agricultural Sciences, Bangalore (UAS), Punjab Agricultural University, Ludhiana (PAU), Indian Agricultural Research Institute, New Delhi (IARI) and The Natural History Museum, London (NHM).

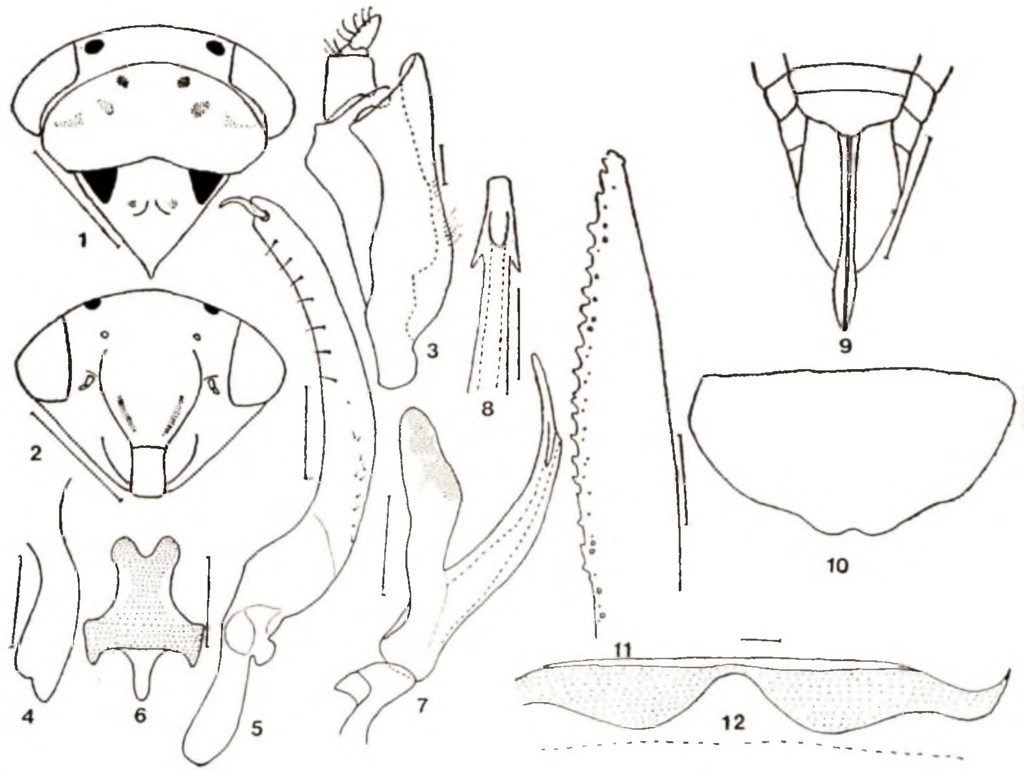
Idiocerus sharmai sp. nov. (Figs. 1–12).

Pale ochraceous. A round spot on either side of vertex closer to adjacent eye than to each other black. Elongate stripe on lateral aspect of clypeus fuscous. Disc of antenna in male black. Pronotum with black and fuscous spots as shown in Fig. 1. Basal triangles of scutellum black, in a few specimens an anterior median stripe and posterior paired stripes fuscous in addition to a fuscous spot on either side of median line. Fore wing hyaline, veins brown interrupted by white.

Vertex with interocular distance 7 to 8 times as wide as median length. Pronotum 2.3 to 2.5 times as wide as long. Third tergal abdominal apodemes short, broad not exceeding third tergum. Second sternal abdominal apodemes short not exceeding second sternum.

Male genitalia: Anal collar process bilobed, dorsal lobe longer than ventral lobe. Connective well sclerotized, larger than that in *Idiocerus cedrus*. Style with apophysis smoothly curved dorsally, its apex slightly excavated and with a single stout subapical spine. Aedeagus with well developed but poorly pigmented, slender dorsal apodeme compared to *I. cedrus;* shaft gradually caudodorsally curved.

Female genitalia: Hind margin of seventh sternum medially produced with bilobed structure. Second pair of valvula



Figs. 1–12. *Idiocerus sharmai* sp. nov. 1. Head and thorax; 2. Face; 3. Male pygofer, lateral view; 4. Anal collar process; 5. Style; 6. Connective; 7. Aedeagus, lateral view; 8. Apex of aedeagal shaft, caudal view; 9. Ovipositor; 10. Female seventh sternum; 11. Apex of female second pair of valvula; 12. Male apodemes of abdominal tergum. Scale indicates 1.0 mm in Figs 1,2,9 and 0.1 mm in others.

with closly spaced 20 teeth on cutting edge. Ovipositor extending well beyond pygofer.

Measurements: Male 4.90 to 5.00 mm long, 1.70 to 1.72 mm wide across eyes. Female 5.20 mm long, 1.72 mm wide across eyes.

Material examined: Holotype ♂, INDIA: Himachal Pradesh: Sundarnagar, 18.v. 1975, A. S. Sohi, on *Salix* sp. (UAS). Paratypes: 3 ♂, 1 ♀, data as for holotype (IARI, NHM, PAU, UAS).

Remarks: I. sharmai is very closely related to *I. cedarae* which it resembles. It differs from *I. cedarae* in having poorly developed tergal and sternal apodemes of male abdomen and in having more slender dorsal apodeme of aedeagus and in the shape of the female seventh sternum. This species is named in houour of Dr Baldev Sharma, University of Jammu, Jammu, India.

Idiocerus cedarae sp. nov. (Figs. 13–21).

Colouration as in *I. sharmai* but darker. Facial fuscous stripes in male more elongate. Markings on scutellum darker. Thoracic sterna black.

Vertex with interocular distance 6 to 8 times as wide as median length. Pronotum

2.0 to 2.4 times as wide as long. Third abdominal tergal apodeme very well developed, strongly sclerotized, dark pigmented exceeding length of third tergum. Second sternal apodeme well developed, pigmented reaching posterior margin of second sternum.

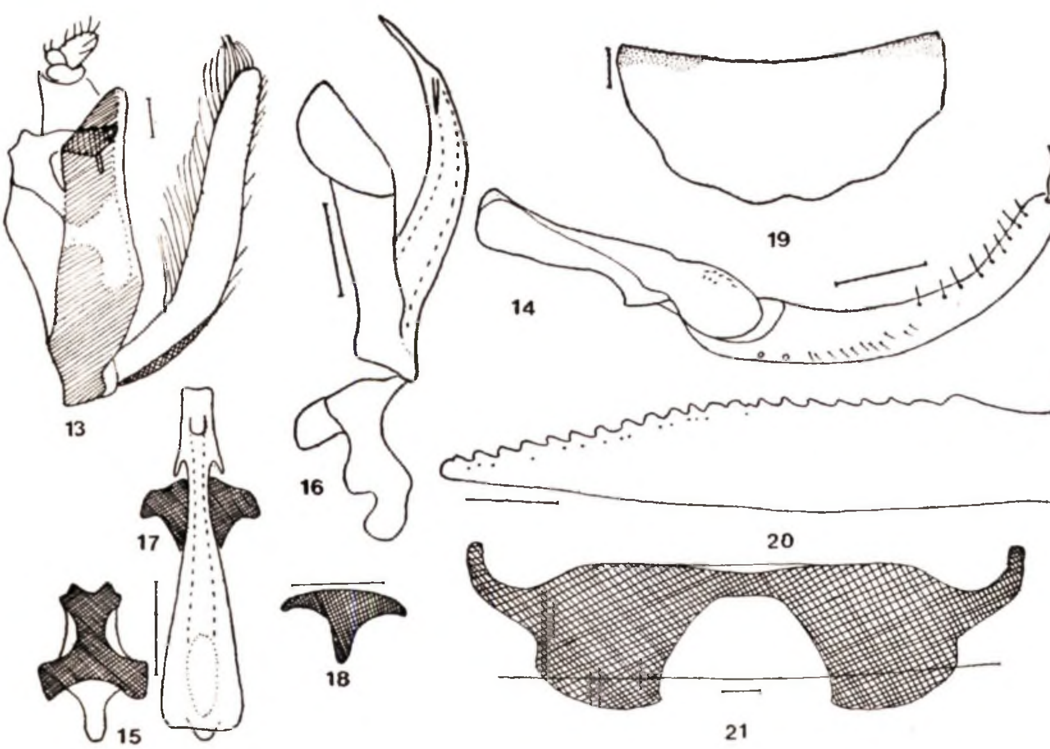
Male genitalia: Anal collar process obliquely truncate. Apophysis of style smoothly curved dorsally with a subapical stout seta. Connective shorter and more slender than that in *I. sharmai*. Dorsal apodeme of aedeagus stout, black pigmented, in dorsal aspect T- shaped, with its arms and stem of equal length, shaft stouter than in *I. sharmai*.

Female genitalia: Hind margin of seventh sternum convexly rounded, medially slightly excavated. Second pair of valvula with 22 closely spaced teeth. Ovipositor extending well beyond pygofer.

Measurements: Male 4.80 to 4.90 mm long, 1.65 to 1.75 mm wide across eyes. Female 5.00 to 5.30 mm long, 1.75 to 1.77 mm wide across eyes.

Material examined: Holotype ♂, INDIA Himachal Pradesh: Kufri, Simla, 2600 m, 15.x.1979, ex *Cedrus deodara*, C. A. Viraktamath (UAS). Paratypes: 1 ♂, 4 ♀, data as for holotype (IARI, NHM, PAU, UAS).

Remarks: This species is closely related to *I. sharmai* and can be distinguished from it in addition to the characters mentioned under that species by its stouter body.



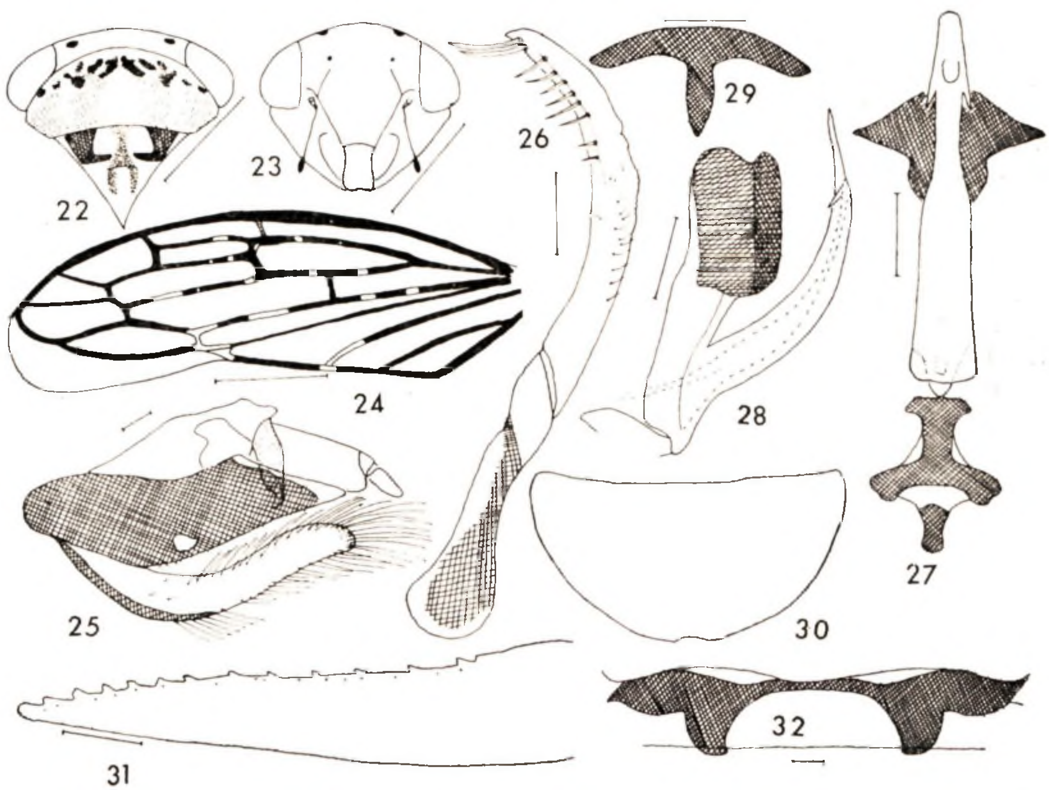
Figs. 13–21. *Idiocerus cedarae* sp. nov. 13. Male pygofer and subgenital plate; 14. Style; 15. Connective; 16. Connective and aedeagus, lateral view; 17. Aedeagus, caudal view; 18. Dorsal apodeme of aedeagus, dorsal view; 19. Female seventh sternum; 20. Apex of female second pair of valvula; 21. Male apodemes of abdominal tergum. Scale indicates 0.1 mm.

Idiocerus deodarae sp. nov. (Figs. 22–32).

Ochraceous with brown and black markings as shown in Fig. 22. A spot on either side of vertex closer to adjacent eye than to each other black. Male antennal disc black. Pronotum with a transverse row or irregular black spots and with a pair of broad brown patch one on either side of mid line. Basal triangles of scutellum black with a mesal extension, median stripe forked apically dark fuscous. Fore wing with dark brown veins interrupted with white markings as in Fig. 24 and basal spot on mid tibia, area between R_1 and R_2 of hind tibia, fore and mid tarsi, apices of hind tarsomeres fuscous. Thoracic sterna chocolate brown margined by yellow. Upper part of face and vertex, an arcuate narrow band across face beneath ocelli dark fuscous in female.

Vertex with interocular distance 6 to 8 times as wide as median length. Pronotum 2.2 to 2.5 times as wide as length. Tergal apodemes of the third abdominal segment well developed, black, not exceeding third tergum. Second abdominal sternal apodemes elongate, reaching middle of third sternum.

Male genitalia: Male pygofer dark pigmented except a ventromedial round hyaline area. Anal collar process hook-like. Apophysis of style with finely serrated



Figs. 22–32. *Idiocerus deodarae* sp. nov. 22. Head and thorax; 23. Face; 24. Fore wing; 25. Male pygofer and subgenital plate; 26. Style; 27. Connective and aedeagus, caudodorsal view; 28. Aedeagus, lateral view; 29. Dorsal apodeme of aedeagus, dorsal view; 30. Female seventh sternum; 31. Apex of female second pair of valvula; 32. Male apodemes of abdominal tergum. Scale indicates 1.0 mm in Figs 22, 23 and 0.1 mm in others.

ventral margin, its apex not excavated with two stout subapical spines. Connective black pigmented. Dorsal apodeme of aedeagus very stout, sclerotized, black, in dorsal aspect T-shaped with arms longer than stem, aedeagal shaft gradually curved caudodorsally.

Female genitalia: Hind margin of seventh sternum hemispherically rounded, with a median concave excavation. Ovipositor slightly exceeding pygofer. Second pair of valvula with 12 widely spaced teeth.

Measurements: Male 5.10 to 5.40 mm long, 1.75 to 1.80 mm wide across eyes. Female 5.30 mm long, 1.82 mm wide across eyes.

Material examined: Holotype ♂, INDIA: Himachal Pradesh: Kufri, Simla, 2600 m, 15.x.1979, ex *Cedrus deodara*, C.A. Virakatamath (UAS). Paratypes: 1 ♂, 1 ♀, data as for holotype (IARI, NHM).

Remarks: Both *I. cedarae* and *I. deodarae* were found feeding on *Cedrus deodarus* often on the same tree. *I. deodarae* is only distantly related to *I. cedarae* and *I. sharmai*. It differs from both of them in its darker colouration and different type of second pair of female valvula.

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TWO NEW SPECIES OF FIG WASPS (HYMENOPTERA: AGAONIDAE) FROM KERALA, INDIA

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Two new species of agaonid fig wasps, *Waterstoniella keralensis*, reared from the figs of *Ficus talboti* King and *Platyscapa beddomei* obtained from *F. beddomei* King are described. Their affinities are discussed.

(*Key words*: two new species, *Waterstoniella*, *Platyscapa*, Agaonidae, *Ficus talboti*, *F. beddomei*)

The two new species of fig wasps described in this paper, viz., *Waterstoniella keralensis* and *Platyscapa beddomei* are the agaonid pollinators of two species of figs from Kerala. The genus *Waterstoniella* is recorded from India for the first time. Both these *Ficus* species, viz., *F. talboti* and *F. beddomei* belong to the section Conosycea (Corner, 1965). It should be noted in this connection that the *Ficus* spp. of the series Validae (which includes *F. beddomei*) of the section Conosycea are generally pollinated by species of *Dielagaon*. As an exception to this, Wiebes (1977) pointed out an instance of a *Platyscapa* sp. from India which pollinates *F. arnottiana* of the series Validae. The present finding of one more species of *Platyscapa* from another *Ficus* of the same series is the second record of such an association from India.

The specimens are deposited in the collections of Department of Zoology, University of Calicut (ZDC).

1. **Waterstoniella keralensis** sp. nov. (Figs. 1–13).

Female: Length 1.1 mm; protruding part of ovipositor 0.5 mm long. Colour of head, thorax and abdomen dorsally dark brown; legs, other parts of thorax and abdomen pale yellowish brown.

Head: Width across the compound eyes larger than its own length (26 : 21); longitudinal diameter of compound eye almost twice as long as cheek (10:6); ocelli 3; epistomal margin (Fig. 1) with a median prominence and two lateral concavities, and bear setae. Antenna (Fig. 2) eleven segmented; scape length width ratio 11:7; pedical less than half the length of the scape; acuminate appendage of the 3rd segment reaching beyond the base of the 5th; 4th and 5th segments almost equal in length; segments 5 to 10 definitely broader than the preceding segments; segments 5 to 11 cup-shaped and bear on their distal margin a row of long sensillae which exceed far beyond the apex of the following segment. Mandible (Fig. 3) longer than wide (8 : 6); apical tooth particularly prominent; subapical slight; three ventral lamellae, not distinct; only one mandibular gland; mandibular appendage with eleven prominent teeth - like lamellae. Labio-maxillary complex as in Fig. 4; labium reduced.

Thorax: One and a half times as long as its maximum width (12 : 8); pronotum almost five times as long as wide (29 : 6).

Figs. 1–13 *Waterstoniella keralensis* sp. nov. 1–8, female holotype; 9–13 male. 1. Epistomal margin; 2. antenna; 3. mandible; 4. labio-maxillary complex; 5. fore wing venation; 6. fore leg tibia and tarsus; 7. hind leg tibia and tarsus; 8. hypopygium; 9. male; head and thorax; 10. antenna 11. mandible; 12. fore leg tibia ad tarsus; 13. hind leg tibia and tarsus.

(Scale: Figs. 1–8, 11, 12 & 13 × 50; Fig. 10, × 112; Fig. 9, × 25).

Fore wing (2:1) 0.95 mm long; submarginal, marginal, stigmal and postmarginal veins (Fig. 5) approximately in the ratio 8:5:3:2. Hind wing (4 : 1) 0.43 mm long. Fore tibia (Fig. 6) with two dorsal teeth and one conspicuous ventral tooth; tarsal segments approximately in the ratio 3 : 2 : 2 : 2 : 8. Tarsal segments of mid leg in the ratio 4 : 4 : 4 : 3 : 5. Hind tibial armature (Fig. 7) consists of an axial, long, curved tooth and an anti-axial tricuspid tooth; tarsal segments in the ratio 5:4:3:3:3:6.

Gaster : Stigmal peritremata of the 8th urotergum oval in outline; protruding part of the ovipositor slightly longer than the abdomen (15 : 13). Hypopygium as in Figure 8.

Male: Length 0.9 mm. Colour pale yellowish brown. Head (Fig. 9) almost as long as wide (22 : 23). Compound eyes larger than cheek (5 :4); posterior angles of the head rounded; posterior margin feebly convex. Antenna (Fig. 10) 5 segmented; scape less than twice as long as

pedicel (5 : 3) and one and a half times its own width (4 : 6); funicle consists of two subequal segments; club (16 : 13) almost as long as scape, indistinctly divided. Mandible (Fig. 11) one and two thirds long as wide (10 : 6), bidentate with one gland.

Thorax: Prothorax of uniform width, almost three-fourths the maximum width of the head. Mesonotum and metanotum incompletely separate; posterior part of the thorax slightly wider. Fore tibia (Fig. 12) with a prominent axial tooth; tarsus two segmented (2:3). Mid leg tarsal segments in the ratio 3 : 3 : 3 : 2 : 4. Hind tibia (Fig. 13) with two apical teeth, one slender and long and the other short and bi-cuspid; tarsal segments approximately in the ratio 6 : 3 : 3 : 3 : 8.

Gaster: Genitalia simple.

Type-material: Series ♀♂, India, Kerala, Calicut, 25.ii.1992 (*coll.* Priyadarsanan D.R.) from the sycones of *F. talboti* King (*det.* C.C. Berg); ♀ holotype, 3 ♀ paratypes and 2♂ paratypes slide mounted, ZDC. Slide Nos. AI-1, 1a, 1b, 1c and Al-2a, 2b, respectively.

Remarks: *Waterstoniella keralensis* resembles *W. sumatrana* Wiebes (Wiebes, 1982). However, the new species differs from it with respect to the following characters: For the female, the atennal scape has a length width ratio of 3 : 2, (while it is 3 : 1 in *W. sumatrana*); the funicular segments bear long sensory setae that project out from the segments (while *W. sumatrana* bear one row of sensillae only). The mandibular appendage bears eleven lamellae (while in *W. sumatrana* only six lamellae are present).

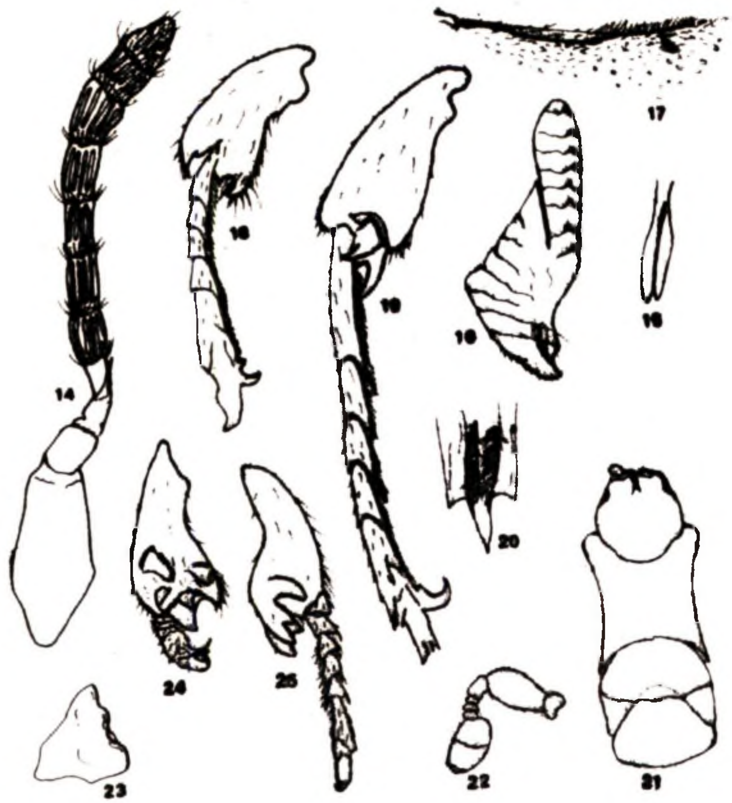
In the case of the male, the antenna is five segmented (it is 4 segmented in *W. sumatrana*); the fore leg tarsus has only two segments (while in *W. sumatrana* it is divided into 5 segments in the antiaxial aspect).

2. **Platyscapa beddomei** sp. nov.

Female: Length 2.27 mm; protruding part of ovipositor 2.46 mm. Colour dorsally black; legs, antennal scape, ventral part of thorax and posterior and ventral aspects of gaster pale yellow.

Head: Width across the compound eyes slightly larger than the length (11 : 10); the longitudinal diameter of eye twice the length of cheek (2 : 1); three ocelli; epistomal margin with two distinct lateral lobes and a weak median prominence. Antenna (Fig. 14) eleven segmented, scape twice its width, three times as long as pedicel; acuminate process of the 3rd segment reaching apex of the 4th; segments 5 to 8 subequal; 9th, 10th and 11th segments form a club which is three times its maximum width; segments from 5th onwards with a row of long sensillae. Mouth-parts; the labium reduced; maxilla (Fig. 15) elongated and with minute pubescence; mandible (Fig. 16) bidentate; longer than its own width (14 : 11); two glands; mandibular appendage with 8 lamellae, each bearing conspicuous teeth-like projections on their ventral side.

Thorax: The anterior margin of pronotum converging forward, posterior margin concave; the length of pronotum two-thirds its width; peritremes of the propodeal spiracles elliptical in outline, situated obliquely near the entero-lateral margins of the pronotum. Fore wing (Fig. 17) (2 : 1) 1.7 mm long; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio 14 : 6 : 1 : 4 : 5; disc pubescent. Hind wing (7 : 2) 0.88 mm long. Fore leg tibial armature (Fig. 18) consisting of a pair of dorso-apical teeth of unequal size and a ventral bi-cuspidate tooth; the



Figs. 14–25. *Platyscapa beddomei* sp. nov. 14–20, female holotype; 21–25 male. 14. antenna; 15. labio-maxillary complex; 16. mandible; 17. fore wing venation; 18. fore leg tibia and tarsus; 19. hind leg tibia and tarsus; 20. hypopygium; 21. male: head and thorax; 22. antenna; 23. mandible; 24. fore leg tibia and tarsus; 25. hind leg tibia and tarsus.

(Scale: Figs. 14–20 and 22–25, × 50; Fig. 20, × 17).

tibia bears a few conspicuous spines close to the ventral tooth; tarsal segments in the ratio 8 : 3 : 3 : 3 : 9. Mid leg tibia almost equal in length to tarsus; it bears a long conspicuous spine at its apex; tarsal segments in the ratio 10:5:4:4:8. Hind leg tibia (Fig. 19) with a elongated bifid axial spur and an anti-axial, broad, bicuspid tooth; tarsal segments in the ratio 2 : 1 : 1 : 1 : 2.

Gaster: One and a half times as long as its height; hypopygium (Fig. 20) bears two long spines and two rows of setae on their sides; protruding part of ovipositor twice the length of abdomen.

Male: Colour yellowish brown; mandible, head and thorax slightly darker.

Head (Fig. 21) : Definitely wider than long (8 : 7); posterior margin prominently convex in the middle; longitudinal diameter of compound eye one third the length of cheek; antennal groove reaches only about one-fourth the length of head. Antenna (Fig. 22): scape four times as long as pedicel; 3rd, 4th and 5th segments are annular and subequal; the length of pedicel, 3

annular segments taken together and the club in the ratio 2 : 3 : 5; club divided into two segments; its width distinctly less than that of scape. Mandible (Fig. 23) distinctly longer than wide (12 : 10), bi-dentate; maxillo-labial complex reduced.

Thorax: Length over twice its width (85:40) lateral margins slightly concave; mesonotum and metanotum fused, one and a half times as wide as its maximum length; propodeum two-thirds its width (25 : 38); peritremes of the propodeal spiracles large and oval shaped. Fore leg tibia (Fig. 24) over twice as long as wide and half the length of femur, with three prominent dorsal teeth and one prominent ventral tooth: tarsal segments approximately in the ratio 4:1:1: 1: 3. Mid leg tarsal segments in the ratio 1:1:1:1:2. Hind leg tibia (Fig. 25) two and a half times as long as wide; the antiaxial crest consists of 3 stout teeth; the axial tooth large and widely bifurcated at the apex; tarsal segments approximately in the ratio 5 : 2 : 2 : 2 : 6.

Gaster: One and a half times as long as its height.

Type material: Series ♀ ♂, India, Kerala, Wynad, Vythri, 28.xi.1990 (*coll.* D. R. Priyadarsanan) reared from the sycones of *Ficus beddomei* King; (*det.* C. C Berg)♀ holotype, 2 ♀ paratypes and 2 ♂ paratypes slide mounted, ZDC. Slide Nos. AII-1, 1a, 1b. and AII- 2a, 2b respectively.

Remarks: This species is closely related to *Platyscapa arnottiana* Abdurahiman (Wiebes & Abdurahiman, 1980), but differs in certain features. The female can be distinguished by the difference in the antenna; the flagellar segments are of uniform width in *P. beddomei* while in *P. arnottiana* it broadens gradually from 4th segment onwards; scape is broader in *P. arnottiana* and has a length width ratio of 1.5 : 1, while this ratio is 2 : 1 in *P. beddomei*. Compound eyes have longer diameter in comparison to the cheek in *P. beddomei* (2 : 1) than in *P. arnottiana* (4 : 3). Male can be distinguished by a smaller head, compared to pronotum in *P. beddomei* than in *P. arnottiana*. Length width ratio of mandible in *P. beddomei* is 1.2 : 1 while in *P. arnottiana* it is 1.75 : 1. Antenna groove reaching only one-fourth the length of head in *P. beddomei* while it reaches one third the length of head in *P. arnottiana*.

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TAXONOMIC STUDIES ON *APHELINUS* (HYMENOPTERA: APHELINIDAE). VI. RECORDS OF TWO KNOWN AND DESCRIPTIONS OF TWO NEW SPECIES FROM THE ORIENTAL REGION

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(*Received* 1 *July* 1992)

Aphelinus chaonia **Walker from Pakistan and *A. maidis* Timberlake from Myanmar, are recorded. Two new species of the genus are described, one based on specimens collected in Sri Lanka and India, and the second from Hong Kong.**

(*Key words:* Aphelinidae, *Aphelinus*, four Oriental species)

The present paper is the sixth in a planned series on the taxonomy of the genus *Aphelinus* Dalman. In some of these papers (Hayat, 1990, 1991 a, b) the author proposed a new subgenues, *Indaphelinus* Hayat, commented upon the systematic position of *Mesidiopsis* Nowicki (Hayat, 1990), dealt with the Nepalese species (Hayat, 1991b), and provided notes on the types of *A. japonicus* Ashmead (Hayat, 1991a). In this contribution, two new species are described, one each from Hong Kong, and Sri Lanka and India. Also two known species, *A. chaonia* Walker and *A. maidis* Timberlake, are recorded based on material collected in Pakistan and Myanmar respectively. The material included in this study was received from the C.A.B. International Institute of Entomology, London, and returned for deposition in the collections of the Natural History Museum, London.

The slide mounted specimens carry numbers which begin with the alphabets 'Ap.'.

1. **Aphelinus chaonia** Walker (Figs. 12, 13)

Material examined: – PAKISTAN: Kohat, 4 females (Ap. 63, Ap. 99), 13. ii. 1963, CIE 19027 CIBC 2842. Determined as *Aphelinus chaonia* Walker by R. D. Eady 1964.

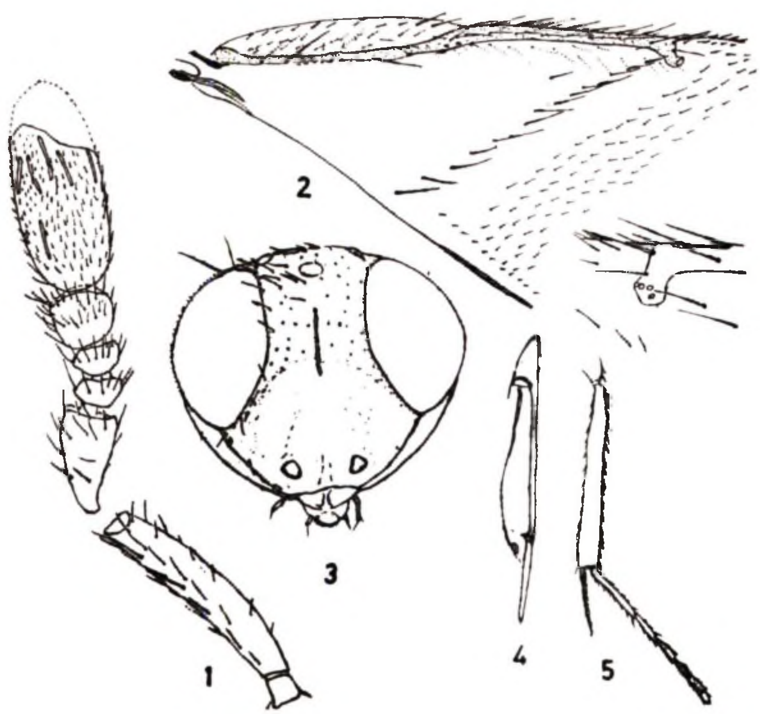
The following specimens are assigned to this species with some hesitation as these have lesser number of setae proximad of the linea calva of fore wing, these forming one complete and one incomplete lines; and in the male two setae are present in the basal cell.

PAKISTAN: Rawalpindi, 1 female (Ap.58), 7.iv.1986, CIE.A. 17886/5125, ex *Aphis gossypii*, CIBC. Peshawar, 1 male (Ap. 57), 19.i.1962, ex aphid on rose, 1884, CIE, Coll No. 18414.

Distribution: Oriental: Pakistan, Hong Kong (Palaearctic, Nearctic, Neotropical).

2. **Aphelinus maidis** Timberlake

Material examined: BURMA (= MYANMAR) Maymyo, Mandalay Div., 2 females (Ap. 128), 28.iv.1989, ex *Cryptosiphum artemisiae* Buckton (G.W. Watson det.) on *Artemisia*, G. Pierrard; sp. 89/D49.



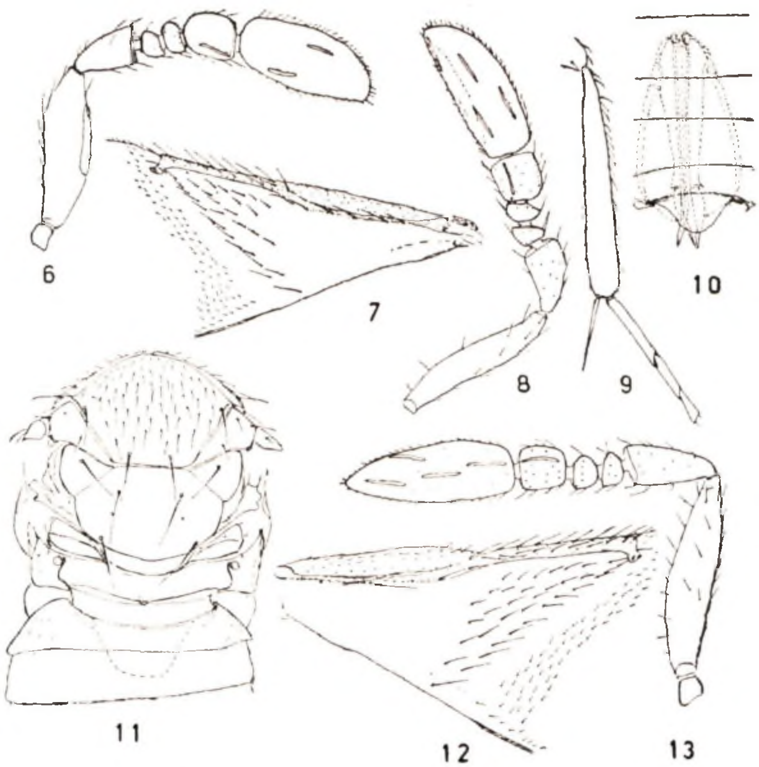
Figs. 1–5. *Aphelinus hongkongensis*, sp. nov., holotype female: 1. antenna, clava broken off distally; 2, part of fore wing with distal veins enlarged; 3, head frontal; 4, second valvifer and third valvula; 5, middle tibia and tarsus, drawn on same scale as Fig. 4.

Distribution: Oriental: Myanmar (Pacific: Hawaii Islands).

3. **Aphelinus hongkongensis,** sp. nov. (Figs. 1–5).

Female:– Length, 1.13 mm. Head and thorax dark brown to nearly black; gaster pale honey yellow with TII onwards with pale brown yellow bands; exserted part of ovipositor sheaths yellow. Scape pale yellow, pedicel and flagellum honey yellow. Wings hyaline, fore wing with a slight yellow tinge on disc below venation. Legs, including fore and middle coxae, pale yellow; hind coxae, except pale apices, dark brown; hind tibiae distally suffused with brown; hind basitarsus brownish; apical fifth or so of dorsal surface of middle femur and middle tibia appear suffused with brown, but this effect produced by dark setae.

Frontovertex width at front ocellus about 0.4 of head width (Fig.3); ocellar triangle with apical angle obtuse, lateral ocelli not more than half their diameter from both eye and occipital margins; eyes densely setose, but setae sort. Antenna as in Fig. 1. Thorax normal for the genus; mid lobe finely reticulate with the cells mostly slightly transversely drawn out; scutellum with hexagonal cells, those on sides longitudinally drawn out. Fore wing about 2.25× as long as broad (68:30); costal cell with a line of setae on dorsal surface and about two lines of setae on ventral surface; linea calva partly closed posteriorly and proximally with one complete line of setae



Figs. 6–13. (6–11), *Aphelinus lankaensis*, sp. nov., holotype female and paratype male: 6, antenna, male; 7, part of fore wing, female; 8, antenna, female; 9, middle tibia and part of tarsus, female; 10, second valvifer and third valvula as seen through the derm, drawn on same scale as Fig. 9; 11, thorax and part of gaster, female. (12, 13), *A. chaonia* Walker, female part of fore wing and antenna.

(Fig.2). Hind wing 3.5× as long as broad (52:15) with the venation nearly 0.66× of wing length. Gaster elongate, conical, longer than thorax (before mounting on slide, 22:18; after mounting on slide, 27:16), with ovipositor sheaths distinctly, though shortly, exserted. Second valvifer plus third valvula about 1.5× as long as middle tibia (37:24); third valvula less than half the length of second valvifer (10.5:26.5) (Figs. 4, 5).

Holotype female (Ap. 124): HONG KONG: Botan. Gdns (= Botanical Gardens), 18.v.1988, ex aphid on *Magnolia coco*, CIE, A 20155. F.D. Bennett sp. 88–194.

Two further specimens on cards with the same data as holotype probably belong to this species, but are not designated as types. One of these, probably a female, has the gaster broken off beyond distal half or so, and the antennae beyond scape missing. The second specimen, a male, is without antennae. It is about 0.8 mm in length and agrees with the holotype except that the gaster is dark brown with yellow base.

Comments: *Aphelinus hongkongensis*, sp. nov. is apparently very close to *A. flaviventris* Kurdjumov (see Graham, 1976; a redescription based on Ukrainian specimens, Chervonenko, 1990). It differs from

flaviventris in having a single line of setae proximad of the linea calva of fore wing; and third valvula about 0.4 × of second valvifer. In *flaviventris*, linea calva proximad with one complete and 1–2 incomplete lines of setae, and third valvula about 0.33 × of second valvifer.

4. **Aphelinus lankaensis,** sp. nov. (Figs. 6–11)

Female: Length, 0.85 mm. Body dark brown to nearly black, base of gaster (=TI and TII) pale yellow. Antennae pale yellow. Wings hyaline. Legs pale yellow to white, with middle and hind coxae dark brown; distal end of middle femur, middle and hind tibiae, and hind tarsi infuscate brown.

Frontovertex about 0.4 of head width; ocellar triangle with apical angle obtuse, lateral ocelli separated from eye margins by less than their own diameter; eyes densely setose, but setae short; otherwise, sculpture and setation normal for the genus. Antenna as in Fig. 8. Thorax normal for the genus (Fig. 11). Fore wing venation and setation as in Fig. 7; in right wing 37 setae proximad of linea calva. Gaster only slightly longer than thorax; ovipositor short, subequal in length to middle tibia (17.0:17.5); third valvula less than 0.5 of second valvifer (5:12) (Figs. 9, 10).

Male: Length, 0.76 mm. Antenna as in Fig. 6.

Holotype female (Ap.65), 1 male **paratype**: SRI LANKA: Maha Illuppallama, 15.x.1962, ex aphids, CIE 18807 No. 5.

The following specimen is conspecific with *lankaensis*, but is not designated as type: INDIA: Karnataka, Bangalore, 1 female (Ap. 81), 27.xii.1988, Coll. M. Hayat.

Comments: The specimen from Bangalore (India) is relatively larger (thorax plus gaster length, 0.88 mm, compared to 0.73 mm of holotype) and has greater number of setae (40–45) proximad of the linea calva; and measured on the same scale as the holotype, the ovipositor, third valvula and middle tibia ratio is 19.0: 7.0:20.0.

A. lankaensis sp. nov. is extremely close to *A. desantisi* Hayat (1972), but differs mainly by the shorter ovipositor which is not longer than the middle tibia; also the gaster except base is dark brown. In *desantisi*, ovipositor always distinctly longer than middle tibia (20–25: 16.5–22.0 n=20), and gaster except base, largely brownish, not as dark as in *lankaensis*.

ACKNOWLEDGEMENTS

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SOME ASPECTS OF METABOLISM OF LIPIDS IN THE MALE ACCESSORY REPRODUCTIVE GLAND, FAT BODY AND HAEMOLYMPH IN *ODONTOPUS VARICORNIS* (DIST.) (HEMIPTERA)

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The increase and maintenance of higher triacylglycerol content in the accessory reproductive gland of *Odonotopus varicornis* during mating and its reduction, both before and after mating, seems to suggest energy contribution by the triacylglycerol to the prolonged mating of this insect. Some triacylglycerol is mobilized from the fat body and/or haemolymph into the gland. Free cholesterol content of the gland also increases considerably during mating without concomitant changes in the fat body and haemolymph.

(*Key words*: *Odontopus varicornis*, triacylglycerol, cholesterol, accessory gland)

INTRODUCTION

To date little is known about the lipid metabolism in relation to reproduction in male insects. Lipid reserves are used as energy sources in different processes such as flight, egg development etc. (SACKTOR, 1975; DOWNER, 1985). Triacylglycerol (TAG) forms the major part of the lipid content of insects during all the developmetal stages (CHINO & GILBERT, 1965). TAG was shown to be an important metabolic reserve in insects (GILBERT, 1967; SACKTOR, 1970, 1976; BEENAKKERS *et al.*, 1981: DOWNER, 1978, 1985) and it was found in the fat body, ovaries and heamolymph (DOWNER, 1985). TAG is also the main source of metabolic energy in insects which undergo prolonged periods of metabolic activity without feeding during diapause, migratory flight and non-feeding developmental stages of embryogenesis and pupation (DOWNER, 1985). The advantages of storing TAG as metabolic reserve are: i) high caloric content/ unit weight, ii) the liberation of metabolic water, in higher quantity as compared to carbo-hydrate and iii) its capacity for storage in anhydrous form. Though some studies indicate that sterols are important for growth, development, reproduction, maintenance of the integrity of cell membranes, imaginal moult, as a precursor for ecdysteroid synthesis and other unknown physiological functions, there are practically no studies dealing with sterols in male insects in relation to their role in reproduction (SVOBODA & THOMPSON, 1985). Hence it was thought worthwhile to study TAG, free cholesterol, ester cholesterol and total cholesterol in the accessory reproductive glands (ARG), fat body and haemolymph in males of *Odontopus varicornis* which remain in copula for most of the time during their adulthood.

MATERIAL AND METHODS

Odontopus varicornis collected from orchards, fields and gardens of the University campus, Annamalainagar, India, were

reared in cages (50×50×50 cm) under laboratory condiiton at 28 ± 2°C and 70% RH. The bugs were fed daily with germinated cotton seeds. The insects remain in copula almost throughout its adult life except for brief intervals after each of the two ovipositions and during the first five days after imaginal moult and towards the approach of senescence. Six days old adult males represent before mating stage, males separated from copulating pair represents during mating stage and males leaving after prolonged copulation represent after mating stage. Each estimation is repeated three times and for each estimation fifteen animlas were sacrificed.

Estimation of triacylglycerol:

FOSTER & DUNN'S (1973) colorimetric method is employed for the quantitative estimation of triacylglycerols. A known amount of ARG tissue was taken and homogenised in 4 ml of isopropanol. 0.01 ml of haemolymph was taken out to which 4 ml of isopropanol was added. 400 mg of washed alumina (or) zeolite was added and placed in a mechanical rotator for 15 minutes and centrifuged at 2000 rpm for 5 minutes. 2 ml of supernatant was added to 0.6 ml of saponifying agent (50 g potassium hydroxide was dissolved in 600 ml water and to it 40 ml of isopropanol was added) and incubated at 60° to 70° C for 15 minutes. Then the contents were cooled and to it 1 ml of metaperiodate solution (Metaperiodate solution was prepared by dissolving 77 g of anhydrous ammonium acetate in about 700 ml of distilled water to which 60 ml of glacial acetic acid and 650 mg $NaIO_4$ were added and when dissolved made up to a litre with distilled water) and 0.5 ml acetyl acetone reagents are added. The contents were incubated once again at 50°C for 30 minutes, cooled and the colour is read in a colorimeter at 405 nm against the reagent blank.

Estimation of free and ester cholesterol using digitonin precipitation:

Free and ester cholesterol content in the tissues were estimated by the method of VENUGOPALA-RAO & RAMAKRISHNAN (1973). Tissues to be estimated were removed fresh from animals and homogenised in a mixture of ethanol and ether (3:1). The mixture has been heated gently in a boiling water bath in a stoppered test tube for about 5 hours. The sample was then centrifuged at 5000 rpm, the supernatant was collected and evaporated. The free cholesterol was precipitated by adding 0.5% digitonin. The ester cholesterol was separated by adding 10 ml petroleum ether (40–60°C). The supernatant was removed from the test tube to estimate the ester cholesterol. Both the free and ester cholesterol samples were kept in a waterbath for evaporation and the cholesterol was determined colorimeterically by the Liebermann-Burchard reagent at 610 nm (Liebermann-Burchard reagent is prepared just before use by mixing 40 ml of acetic anhydride with 20 ml of acetic acid to which 5 ml of concentrated H_2SO_4 is added.).

OBSERVATIONS

The ARG shows a significant amount of triglycerides content before mating and tends to increase considerably during mating. It returns again to the pre-mating level, three hours after mating (Table 1). Quite interestingly, the fat body contains just half the quantity of TAG as compared to that of the accessory gland and the trend of increase and decrease during and after mating is similar to that of the gland. The haemolymph exhibits initially a low content of TAG but increase significantly during mating and to a still higher level after mating.

TABLE 1. Triacyglycerol, free and ester cholesterol in the accessory reproductive gland, fat body and haemolymph in *Odontopus varicornis* before, during and after mating.

Stage	Type of lipid	Accessory gland (mg/g)	Fat body (mg/g)	Haemolymph (mg/ml)
	Triacylglycerol	133.6±13.2	64.4±3.2	4.31±0.35
Before mating (n=3)	Free cholesterol	2.0±0.3	52.0±3.7	0.56±0.003
	Ester cholesterol	—	168.0±14.6	—
	Total cholesterol	2.0±0.3	220.0±16.5	0.56±0.003
	Triacylglycerol	193.0±7.5*	118.5±7.2[a]	10.64±0.87
During mating (n=3)	Free cholesterol	48.0±3.8	56.5±5.1	0.24±0.002
	Ester cholesterol	4.0±0.5	2.0±0.4	—
	Total cholesterol	52.0±3.4[b]	58.0±6.2[b]	0.24±0.003
	Triacylglycerol	134.4±13.9	47.7±4.0*	14.71±1.7[a]
After mating (n=3)	Free cholesterol	5.5±0.8	51.7±4.3	0.51±0.05
	Ester cholesterol	—	64.0+4.4	—
	Total cholesterol	5.5±0.8	115.7±5.5	0.51±0.05

Mean ± SE *$P<0.05$; [a]$P<0.01$; [b]$P<0.001$

The fat body shows the presence of a moderate quantity of free cholesterol, whereas the ARG and haemolymph show only a small quantity of free cholesterol before mating. During mating, while the free cholesterol remains more or less the same in the fat body, it decreases by more than 50% in the haemolymph and increases drastically in the gland (from 2.0 mg/g to 48.0 mg/g). While the free cholesterol level, after mating, returns to its premating level in the fat body and haemolymph, it remains slightly higher than the premating level in the ARG. Ester cholesterol is absent both in the gland as well as in the haemolymph, before and after mating, and after mating, although a small quantity of it appeared in the gland but not in the haemolymph during mating. The ester cholesterol content in the fat body was high before mating (168.0 mg/g) but declined drastically (2.0 mg/g) during mating to increase again moderately after mating.

DISCUSSION

Previous studies on *Odontopus varicornis* have shown that this continuously mating bug might require constant supply of energy to sustain this odd and characteristic behaviour of this bug (JAYAKUMAR, 1989; BASKER & RANGANATHAN, 1987). Since prolonged and continuous mating might not be satisfied with energy supplied from carbohydrates in *Odontopus varicornis* the observed increase in TAG content of the gland during mating, might support the higher energy requirements as in the case of sustained

fliers like the locusts which utilize TAG during prolonged flights (DOWNER, 1985).

Fat body and haemolymph are known to contribute the precursor materials that are used up in the elaboration of the secretion by the male accessory gland in some insects (FRIEDEL & GILLOTT, 1976; BASKER & RANGANATHAN, 1987). The increase of the TAG content both in the fat body and haemolymph during mating with a concomitant increse in the gland and again its reduction, after mating, in the fat body suggests the transfer of TAG from the fat body and/or haemolymph to the gland in *Odontopus*.

Sterols are important for growth, development and reproduction in insects and are essential for the integrity of the cell membrane and ecdysteroids can be synthesised from cholesterol. The enormous increase in the free cholesterol level in the ARG of *Odontopus* during mating, without being accompanied by any changes in cholesterol level of either fat body or haemolymph such as metabolic fuel or as precursor of triacylglycerol synthesis as suggested by BEENAKKERS (1985, cited by CHINO, 1985). As a well known important factor for the integrity of the cell membrane, cholesterol of the gland is probably involved in the repair or renovation of the continuously functioning secretory cells of the gland in this bug which remains in copula almost throughout its adult life since free sterols are used as structural components of cells and tissues during periods of rapid growth and development when exogenous sources of sterol is insufficient or unavailable (SVOBODA & THOMPSON, 1985).

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PRESENCE OF FEMALE SEX PHEROMONE IN TEA MOSQUITO BUG, *HELOPELTIS ANTONII* SIGN. (HETEROPTERA: MIRIDAE)[1]

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Attraction due to sex pheromone was studied in males and females of tea mosquito bug by using an olfactometer deviced in our laboratory. It was observed that females started attracting males after becoming 3 day old. Although young females attracted more males, even old females attracted males. These studies indicate the existence of female sex pheromone in tea mosquito bug.

(*Key words*: *Helopeltis antonii*, sex pheromone)

INTRODUCTION

The tea mosquito bug. *Helopeltis antonii* is a serious pest of cashew causing substantial losses due to blossom blight and shoot damage. Even at low population levels, his pest causes severe damage and an estimated yield loss of 30–40% has been reported (DEVASAHAYAM & NAIR, 1986).

Sex pheromones are one of the recent tools employed in insect pest management. Earlier reports have indicated the presence of a sex attractant pheromone in female of *Helopeltis clavifer* (SMITH, 1977), congeneric species of *H. antonii*. However, very little information is available on the existence of sex pheromone in the tea mosquito bug. The present study was therefore undertaken to find out the presence of sex pheromone in tea mosquito bug and influence of age, if any, on the pheromone release so as to use the knowledge in the integrated pest management of this economically important pest.

MATERIALS AND METHODS

Sex attraction studies were conducted with an olfactometer constructed in our laboratory. The olfactometer (Fig. 1) consists of two cubic chambers (30 × 30 × 30 cm) made up of transparent acrylic sheet (3 mm in thickness): one chamber is

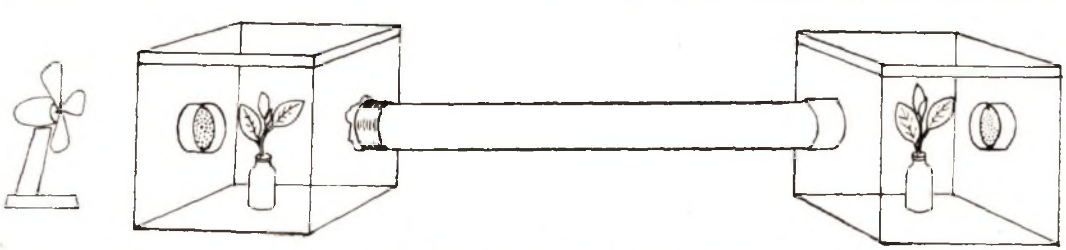

FIG. 1. Line diagram of fully assembled olfactometer.

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designated as bait- and other as test chamber. Each chamber has a removable lid at the top and two protruding circular holes (7.5 cm in diameter) on opposite sides, which in turn are connected by a transparent tube (100 cm length and 7.5 cm diameter) made up of polyester film (175 μm thickness). The holes at the free end were covered with the acrylic sheet lid with sieve holes to allow wind movement. The mouth of the tube at the bait chamber end is covered with muslin cloth to confine the insects to the bait chamber. A single succulent cut cashew shoot dipped in a small glass vial (5 ml) filled with water served as a food source in each of the test and bait chambers.

A mini-table fan (20 cm diameter) with electronic regulator was stationed in front of the sieve hole of the bait chamber so that an air current passed from the bait chamber to the test chamber. The wind velocity was adjusted to 1m/sec. at the time of bioassay.

Every time, the components of olfacto meter were wiped in moist cotton wool dipped in 80% alcohol, followed by washing in detergent soap water and in clean water and followed by rinsing with distilled water and sun drying before starting the experiment. The insects were allowed to acclimatize for one hour in the respective chambers before the bioassay. The bioassays were undertaken mostly in the afternoon hours.

The adults after final moulting (designated as 'O' day) were collected from the laboratory culture, maintained by standard method (SUNDARARAJU & JOHN, 1992) and were sexed and kept in isolation till their use in the experiments.

A preliminary experiment was conducted to assess the presence of sex pheromone in which several batches of virgin females and unmated males comprising 15 individuals each of 1,2, 3 and 4 day old were used. The behavioural response of females and males of known age was assessed by keeping them separately in test and bait chambers. The experiment was repeated with opposite sexes in test and bait chamber and the number of insects reaching the bait chamber was counted in a test period of one hour.

As indication of the presence of sex pheromone was obtained in the preliminary experiment with 3 and 4 days old adults only the experiment was repeated six times with only this age group. A set of blank experiment was run but keeping only food source in the bait chamber.

In order to ascertain the duration of sex attraction during the life span of an adult, fifteen 4 day old females were kept in bait chamber at the start of the experiment with equal number of similar age group males in the test chamber. While the same set of females were kept in bait chamber throughout the experimental period i.e., till the death of last female, the males in the test chamber were replaced every day. Separate experiments were conducted with laboratory cultured virgin females and mated females. The four day old mated females were collected from visually confirmed mated pairs.

Raw data were transformed to $\sqrt{0.5 + X}$ and analysed in completely randomised design (GOMEZ & GOMEZ, 1984). The means were compared with the least significant test (LSD) values.

RESULTS AND DISCUSSION

The females of *H. antonii* attracted the males, as this happened only when an air current was generated through the olfactometer (Table 1), it was evident that the air current carried some volatiles released by

female that resulted in attraction of males, in effect, the possibility of presence of a sex pheromone. The behavioural responses of males that supplemented attraction were antennal movement, rapid walking or running, chasing and mounting on other males and upwind flying. These behavioural responses were not noticed in either females in the test chamber or males maintained in test chamber with only food source in the bait chamber. The present observations differ from the preliminary ones reported earlier (ANONYMOUS, 1988) which indicated the attraction of females by males in *H. antonii*. The present results are in conformity with earlier studies on

TABLE 1. Sex attraction in three to four day old adults of *H. antonii*.

Age of virgin adults (in days)	Sex of adults in bait chamber	No. of adults of opposite sex reaching bait chamber in test peridd
3*	male	0.17 (0.80)a**
3	male	0.83 (1.12)a
4*	male	0.67 (0.99)a
4	male	0.50 (0.90)a
3*	female	1.50 (1.28)a
3	female	5.67 (2.41)b
4*	female	1.17 (1.22)a
4	female	5.83 (2.37)b
3 & 4	blank	1.67+ (1.37)a
3 & 4	female	7.00 (2.69)b
2*	male	1.0"
2	male	0.0"
1*	male	0.0"
1	male	0.0"
2*	Female	2.0"
2	Female	3.0"
1*	Female	0.0"
1	Female	0.0"

* No fan was operated. Mean of six replications pertaining to three and four day old adult groups only.

** Figures in parentheses are transformed values.

Means within a column followed by the same alphabet are not significantly different at 5% (LSD).

+Only males were maintained at test chamber.

"Based on preliminary experiment.

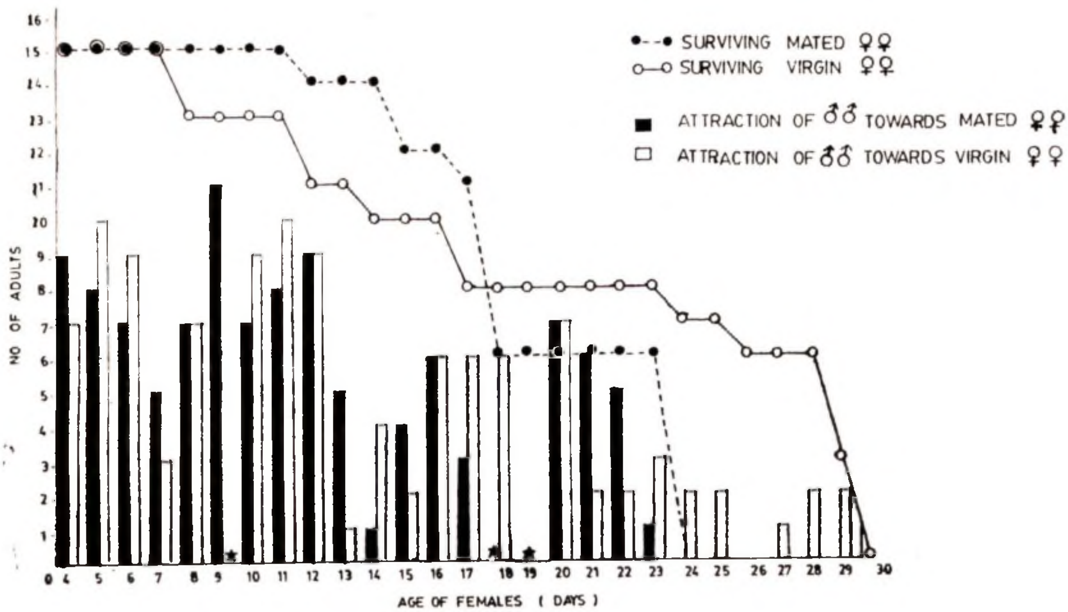

FIG. 2. Attraction of males by females (virgin/mated) of different ages.

* No data due to power failure i.e., on 9th day from virgin ♀♀ and 18 & 19th day from mated ♀♀ group.

Mean attraction :	Towards mated ♀♀	=	6.1 (2.5)
	Towards virgin ♀♀	=	4.6 (2.1)
	S.E.	=	(0.22)

Figures in bracket are transformed values and statistically non-significant.

eight other species of mirids (SCALES, 1968; STRONG *et al.*, 1970; KING, 1973; SMITH, 1977; BOVIN & STEWART, 1982; SLAYMAKER & TUGWELL, 1984; GRAHAM, 1987; THRISTLEWOOD *et al.*, 1989).

Females started attracting males when 3 day old. This period coincides with 1) the end of pre ovipositional period and 2) the first appearance of mature eggs, especially in the mirids (STRONG *et al.*, 1970; KING, 1973; SMITH, 1977). Females of all ages showed some degree of attraction to males (Fig. 2). Even after mating, females could attract male (Fig. 2) and this observation corresponded with the multiple mating habit of *H. antonii* (JEEVARATNAM & RAJAPAKSE, 1981). In two other species of mirids however, the sex attraction either wanes after single mating as in *Distantiella theobroma* (KING, 1973) or resume one week after the first mating as in *Lygus hesperus* (STRONG *et al.*, 1970). Although no data is presented here, it was found in general that *H. antonii* females continued to attract the males throughout the day as in other mirids, *L. hesperus* (STRONG *et al.*, 1970) and *H. clavifer* (SMITH, 1977). The mating couples generally observed at any time of the day both in the laboratory and in the field (DEVASAHAYAM, 1988) strengthen this view.

STRONG *et al.* (1970) suspected that in mirids reproductive organs particularly spermatheca secretes sex pheromones. However, studies on *Campylomma verbasci* (Meyer), a mirid indicate that head and thorax secrete the sex pheromone in this species (THRISTLEWOOD *et al.*, 1989). Studies on the morphology of pheromone glands and their function along with the identification and synthesis of active components of pheromones are necessary in *H. antonii* for further exploitation of this technique in integrated pest management programme.

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SEASONAL ABUNDANCE AND VERTICAL DISTRIBUTION OF PURPLE MITE, *CALACARUS CARINATUS* (GREEN) (ERIOPHYIDAE: ACARINA) INFESTING TEA

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The purple mite, *Calacarus carinatus* (Green) is an important pest of tea, *Camellia sinensis* (L.) O. Kuntze. In Munnar, Kerala, at 1500 m elevation, population density of this mite on tea leaves was high during January to April. Heavy rainfall, high temperature and high percentage of relative humidity significantly reduced the number of mites. On tea bushes, they preferred the leaves at the bottom level; leaves at the top and middle level harboured significantly low population of mites. The density of *C. carinatus* was higher on bushes in the third and fourth years from pruning than on bushes in the first half of the pruning cycle.

(*Key words*: purple mite, *Calacarus carinatus*, seasonal abundance, vertical distribution, tea pest, *Camellia sinensis*, Kerala)

INTRODUCTION

In south India, tea (*Camellia sinensis* (L.) O. Kuntze) is cultivated in Karnataka, Kerala and Tamil Nadu covering an approximate area of 83,000 ha. This plantation crop is attacked by six species of mites in this part of the country (MURALEEDHARAN, 1991). Among them, the purple mite *Calacarus carinatus* (Green), and the pink mite *Acaphylla theae* (Watt), are the most common pests. Infestation by purple mites results in coppery brown leaves and debilitation of bushes, leading to crop loss. However, we have no information on the ecology of *C. carinatus* under the agroclimatic conditions of Kerala. In view of this, an experiment was carried out to study the seasonal abundance and within-plant distribution of *C. carinatus* in a tea field at Munnar in Kerala.

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MATERIALS AND METHODS

A field planted with 'China hybrid' tea was selected for the study. The experimental area consisting of 200 tea bushes, was located in Munnar (Idukki District: Kerala State), at an altitude of 1500 m above MSL. These bushes, planted at a spacing of 1.2 × 1.2 m, were pruned in 1987 at a height of 60 cm above ground level; the field was kept free from pesticide application since pruning. Sampling for mites was started in September 1988. Two hundred and forty leaves were collected from 40 bushes at random. From each bush, six leaves were examined, two each from the top, middle and bottom levels. In the present study, leaves from the top 10 to 15 cm of the bushes (plucking table) were considered 'top level leaves' and those present on the bushes up to a height of 45 cm above ground level were treated as 'bottom level leaves'. The foliage present between the top and bottom levels was regarded as 'middle level leaves'. Leaves were sampled on the 14th and 28th of

every month. The total number of mites from each leaf was counted under a stereo-binocular microscope. Weather data pertaining to the study period were obtained from the crop weather observatory of the estate.

The statistical significance of the interactions between the different weather factors and mite population was analysed using the microcomputer (PB–110) by substituting the data for exponential regression analysis.

Simple correlations were also made to study the influence of age of the plants since pruning on the incidence of purple mites. For this purpose, data on the number of mites present during the peak periods in the three years of the pruning cycle were utilised.

RESULTS AND DISCUSSION

Four species of mites were observed on the leaves collected from the experimental area and among them *C. carinatus* was predominant, forming 99.54 per cent of the total mite population. Populations of the other three species viz., *Acaphylla theae* (Watt), *Acaphyllisa parindiae* (Keifer) (Eriophyidae) and *Oligonychus coffeae* (Neitner) (Tetranychidae) were low, forming only 0.17, 0.07 and 0.22 per cent, respectively of the total number of mites.

The purple mites were present in varying numbers on leaves at all the three vertical levels throughout the year. Their population gradually increased from November, reached peak in March or April and started declining from May onwards. Fluctuations in the populations of *C. carinatus* for one pruning cycle during September 1988 to July 1991 are depicted in Figure 1.

Data on the numerical abundance of *C. carinatus* at the three vertical levels of tea bushes revealed striking differences (Table 1). Population density of purple mites was significantly high on the leaves at the bottom level and leaves at the top and middle levels harboured very low populations. Further, at all the three levels, these mites preferred the abaxial surface of leaves.

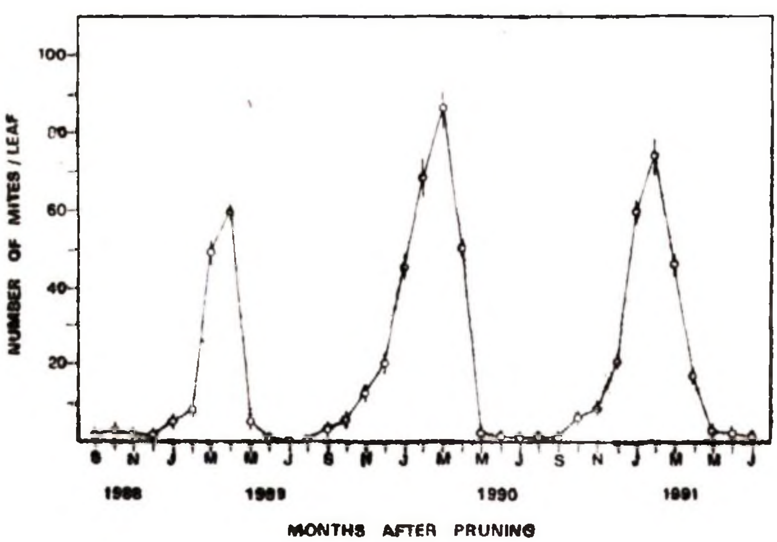

Fig. 1. Population trends of *Calacarus carinatus* on tea at Munnar.

TABLE 1. Mean number of *Calacarus carinatus* per leaf at three vertical levels of tea bushes.

Levels	Mean ± S. E.
Top	1.92 ± 0.20 a
Middle	4.50 ± 0.13 a
Bottom	8.28 ± 0.55 b
C. D. at $P = 0.01$	2.98

Age of the field from pruning showed a positive significant influence on the abundance of *C. carinatus* ($P = 0.05$). Population density of mites on leaves increased as the field advanced in age from pruning ie., the bushes in the third and fourth years of the pruning cycle harboured more number of mites than the younger field (Fig. 2).

Heavy rainfall had a significant negative influence ($P = 0.01$) on the population of mites. Very high as well as very low percentage of relative humidity also significantly reduced ($P = 0.01$) the number of mites (Table 2).

The abundance of *C. carinatus* during the post-monsoon period (November to March/April) could be attributed to the conducive weather conditions like moderately high temperature (24 to 26°C), optimum relative humidity (80 to 90 per cent) and low precipitation (0.5 to 3.0 cm). Heavy rainfall from May to August seems to wash off and kill a large number of the mobile forms from the leaves at all the three vertical strata of tea bushes. DANTHANARAYANA & RANAWEERA (1970) in Sri Lanka and SHIAO (1976) in Taiwan found that populations of *C. carinatus* on tea were adversely affected by rainfall. Similarly, MURALEEDHARAN & CHANDRASEKARAN (1981)

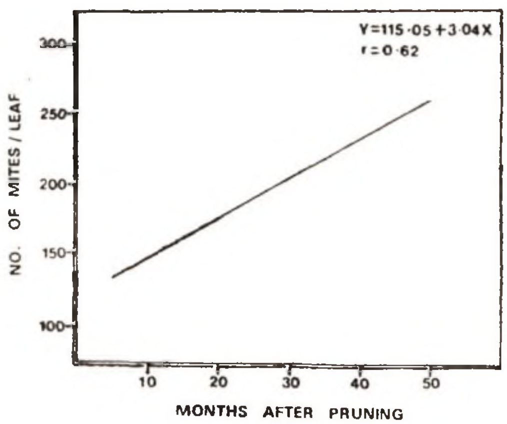

Fig. 2. Relationship between age of the field since pruning and the population density of *Calcarus carinatus* on tea.

TABLE 2. Correlation coefficient (r) of *Calacarus carinatus* population on tea with different weather factors.

Weather factors	a	b	r
Rainfall (cm)	12.28	−0.05	−0.37**
Temperature minimum (°C)	13.28	−1.37	−0.12
Temperature maximum (°C)	22.43	0.004	0.28
Minimum Relative humidity (%)	78.82	−0.005	−0.45**
Maximum Relative humidity (%)	93.05	−0.992	−0.47**

** Significant at 1% level.

and RADHAKRISHNAN *et al.* (1987, 1990) showed that pink mites, *A. theae* in the Anamallais exhibited a negative correlation with rainfall.

Purple mites preferred the leaves at the bottom level of bushes and this observation is in conformity with the results of an earlier study on the vertical distribution of eriophyid mites on tea (MURALEEDHARAN *et al.*, 1988). Mature tea leaves are rich in carotenoids; FERNANDO (1967) correlated the abundance of *Oligonychus coffeae* on mature leaves with their rhodoxanthin content. It is possible that similar preferences for such chemicals are involved in the selection of mature leaves by *C. carinatus*.

Population density of purple mites on tea leaves increased as the field advanced in age from pruning. In Indonesia, OOMEN (1982) found that during the first two years after pruning, population of the scarlet mite *Brevipalpus phoenicis* Geijskes infesting tea multiplied slowly and more or less exponentially and in about two years after pruning, the average population growth levelled off.

The purple mites are not successfully controlled by natural enemies, though two predators viz., *Amblyseius herbicolus* (Chant), (Phytoseiidae) and *Scolothrips rhagebianus* (Priesner) (Thripidae) were collected from the experimental area. Usually, acaricides such as sulphur, dicofol and ethion are applied for the control of purple mites. The present data could be useful for sampling the population and also evolving a suitable strategy for the efficient application of acaricides.

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PARTHENOGENETIC DEVELOPMENT OF OVARIAN EGGS IN SOME BREEDS OF SILKWORM, *BOMBYX MORI* L.

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Parthenogenetic development was induced in ovarian eggs of four poiyvoltine breeds, four bivoltine breeds and two bivoltine bybrids of silkworm, *Bombyx mori* L. Polyvoltine breeds showed lower parthenogenetic ability than bivoltine breeds. Japanese type bivoltines had higher rate of parthenogenesis than Chinese type bivoltines. All parthenotes were females. Quantitative traits of parthenogenetic individuals were inferior. No considerable differences were observed among quantitative traits in the hybrid of parthenogenetic females and bisexual male when compared to the respective bisexual hybrid. Heterosis over MPV and BPV for ERR (%) and cocoon characteristics was higher in the former hybrid than the latter.

(*Key words:* parthenogenesis, quantitative traits, breed, hybrid, *Bombyx mori* L.)

INTRODUCTION

Parthenogenesis is a common method of reproduction in several animals (CUELLAR, 1977; CLEMENT, 1982; CHOWDHURY, 1989) and it is an important tool in silkworm breeding which requires special significance. In silkworm, *Bombyx mori* L, several methods have been tried to activate parthenogenetic development (ASTAUROV, 1957; STRUNNIKOV, 1983; TAKEI *et al.*, 1990). The ability of parthenogenetic development and determination of sexes of parthenotes depend upon the type of method followed for the induction of parthenogenesis (STRUNNIKOV, 1975). Recently, a method for long term preservation of silkworm genetic stocks using ovary freezing transplantation - parthenogenesis system has been developed (SHINBO *et al.*, 1991). Hybrid vigour and parthenogenetic development have been studied in parthenotes of some silkworm breeds (TAKEI *et al.*, 1990).

Perusal of available literature revealed little information on the parthenogenesis in indigenous and exotic silkworm breeds found in India. Hence, the present study has been undertaken to find out ability of parthenogenesis and its influence on manifestation of quantitative traits in some breeds and hybrids of the silkworm, *B. mori* and the results are reported in this paper.

MATERIALS AND METHODS

Silkworm breeds used in this study were 'Pure Mysore' ('PM') and 'Nistari' (indigenous polyvoltines) 'KW_1' and 'P_2D_1' (evolved polyvoltines), 'NB_7' and 'NB_4D_2' (Japanese type bivoltines). A bivoltine hybrid viz., '$NB_7 \times NB_{18}$' and its reciprocal were also tested. The experiment was carried out during January - February 1991 and the method of ASTAUROV (1967) was adopted for the induction of parthenogenetic development.

Ovarian eggs were obtained from freshly emerged virgin moths by squeezing out

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ovarioles. Eggs were washed with tap water and kept at 25°C for 12 h. Then the eggs were heat-treated in water bath at 46°C for 18 min. Soon after the treatment, eggs were transferred to water at room temperature for 10 min. Subsequently, the eggs were dried and incubated at 15°C and relative humidity of 85 to 90 % for 72 h. With the appearance of light brownish serosal colour, eggs of bivoltine breeds and their hybrids were treated with hot hydrochloric acid at 46°C (specific gravity 1.075) for 5 min. The eggs were incubated at 25°C till hatching. The parthenogenetic development of the eggs was identified with the appearance of reddish - brown/ dark pigmentation in the serosa which indicated a sign of embryonic development. The ratio of reddish - brown / dark pigmented eggs and total number of eggs treated was expressed as the percentage of parthenogenetic eggs. Rearing of larvae hatched from parthenogenetic eggs and normal fertilized (bisexual) eggs was carried out simultaneously as per KRISHNASWAMI (1978). Data were recorded for larval span, hatchability, effective rate of rearing (ERR), cocoon weight, cocoon shell weight, cocoon shell ratio and sex in the case of parthenotes. Heterosis was worked out with the following formulae:

1. Heterosis over mid parent value (MPV)

$$= \frac{F_1 - MPV}{MPV} \times 100$$

2. Heterosis over better parent value(BPV)

$$= \frac{F_1 - BPV}{BPV} \times 100$$

RESULTS AND DISCUSSION

Data on parthenogenetic development (Table 1) indicated that the occurrence of parthenogenesis in the ovarian eggs of different silkworm breeds varied greatly,

TABLE 1. Extent of parthenogenetic development in ovarian eggs of different breeds of silkworm, *Bombyx mori* L.

S. no.	Breed/ Combination	Total no. of eggs treated	No. of reddish brown/dark pigmented eggs	Partheno-genicity (%)	No. of hatched eggs	Hatching (%)
1.	Pure Mysore	5935	180	3.03	Nil	—(94.4)
2.	Nistari	5010	32	0.63	nil	—(94.0)
3.	KW_1	5944	22	0.37	nil	—(95.5)
4.	P_2D_1	5837	175	3.46	27	15.4(95.7)
5.	NB_7	5167	2141	48.42	361	16.8(95.9)
6.	KA	4251	1825	50.59	326	17.8(96.4)
7.	NB_{18}	7013	4745	84.25	1164	24.5(96.0)
8.	NB_4D_2	4252	2715	89.18	1077	39.6(97.2)
9.	$NB_7 \times NB_{18}$	8860	5500	79.65	1557	28.3(97.6)
10.	$NB_{18} \times NB_7$	9235	2010	82.71	2010	35.7(96.8)

Figures in parentheses indicate hatchability of fertilized eggs of respective silkworm breeds.

ranging from 0.37% in 'KW_1' to 89.18% in 'NB_4 D_2'. A similar result on parthenogenetic development in some silkworm breeds was also observed by TAKEI *et al.*, (1990). The occurrence of parthenogenesis was lower in polyvoltine breeds (48.42 to 89.18%). Among bivoltine breeds, 'NB_{18}' and 'NB_4 D_2' (Japanese type) had higher percentage of parthenogenesis (84.25 to 89.18%) than that of 'NB_7' and 'KA' (Chinese type) (48.42 to 50.59%). Further, there was no hatching from parthenogenetic eggs in majority of polyvoltines viz.. 'Pure Mysore', 'Nistari' and 'KW_1', though serosa of the eggs showed reddish brown colouration. However, hatchability of parthenogenetic eggs of the breeds studied was poor, ranging from 15.4% in 'P_2D_1' to 39.6% in 'NB_4 D_2' even though pigmentation of serosa reached blue egg stage. It may be concluded that occurrence of partheogenesis and hatchability are controlled genetically.

On examination of sexual markings of 5th instar larvae, it was observed that the sex of all the parthenotes in the present study was found to be female which could be attributed to the destruction of spindle fibres during first meiotic metaphase in parthenogenetic development which resulted in only female progeny (ASTAUROV, 1957).

Comparative rearing performance of parthenogentic and bisexual individuals of the breeds (Table 2) exhibited that there was a reduction in the total larval period in most of the parthenotes as compared to bisexual individuals barring that of 'P_2D_1' and 'KA'. Data on quantitative traits demonstrated that performance of parthenogenetic individuals was inferior to bisexual individuals for ERR (%) ranging from 45 to 71% as against 85 to 95% of bisexual individuals. Female cocoons of bisexual individuals had more weight (1.52 to 2.04 g) than that of the respective parthenotes (0.56 to 1.76 g). A similar trend was also observed with respect to cocoon shell weight and cocoon shell ratio in all the bisexual individuals (24.40 to 39.70 cg and 16.08 to 19.63%) and parthenotes (7.30 to 33.80 cg and 12.97 to 19.24%) tested barring parthenotes of 'NB_4D_2' which exhibited more female cocoon shell weight and cocoon shell ratio than that of its bisexual female individuals. It could be inferred that survival and cocoon characteristics, in general, of the parthenotes were inferior to respective bisexual individuals of the breed studied. Similar observations were also reported by TANAKA (1953) in *B. mori* and by ROTH & WILLIS (1956) in cockroaches for the survival. However, STRUNNIKOV (1975) reported better survival in parthenotes than in most of the bisexual hybrids of the silkworm. *B. mori.* Rearing performance of bivoltine hybrids revealed that no considerable differences were observed in quantitative traits between the hybrid resulting from a parthenogenetic female ('NB_4 D_2)' and a bisexual male ('KA') and its respective bisexual hybrid (Table 2).

Taking eight silkworm breeds/combinations and two types (bisexual and parthenote) as two factors, data on three quantitative traits viz., cocoon weight, cocoon shell weight and cocoon shell ratio with respect to female were analysed according to 8×2 asymmetrical factorial analysis. Different effects were observed among the silkworm breeds/combinations as for the development of their parthenogenetic eggs was concerned. Results of the factor analysis revealed that both parthenote and bisexual individuals differed significantly (at 1% level of significance in their quantitative traits (Table 2).

When hybrid vigour in a bisexual biovltine hybrid and a bivoltine hybrid of female

TABLE 2. Comparative rearing performance of parthenotes and bisexual individuals of breeds/hybrids of the silkworm, *Bombyx mori*.

S. no.	Breed/ Combination		Type	Larval span D:H	ERR (%)		Cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell ratio (%)
1.	P_2D_1	a.	Bisexual	24:12	94.66±1.01	M	1.17±0.01	22.90±0.28	19.58±0.22
						F	1.52±0.03	24.40±0.48	16.08±0.33
		b.	Parthenote	24:12	44.83±0.99	F	0.56+0.02	7.30±0.32	12.97±0.39
2.	NB_7	a.	Bisexual	27:06	85.83±1.45	M	1.71±0.03	40.80±0.84	23.85±0.36
						F	2.02±0.04	39.70±7.64	19.63±0.13
		b.	Parthenote	26:06	53.33±4.37	F	1.32±0.03	23.64±0.92	17.90±0.43
3.	KA	a.	Bisexual	26:06	86.33±1.45	M	1.58±0.03	33.60±0.79	22.13±0.27
						F	1.93±0.05	35.60±0.72	18.46±0.25
		b.	Parthenote	26:06	49.33±2.40	F	1.32±0.11	19.77±1.68	15.83±0.41
4.	NB_{18}	a.	Bisexual	26:06	89.83±2.17	M	1.39±0.18	30.70±0.44	22.19±0.17
						F	1.64±0.03	31.00±0.50	18.98±0.23
		b.	Parthenote	25:06	67.33±2.91	F	1.43±0.03	25.30±0.87	17.72±0.28
5.	NB_4D_2	a.	Bisexual	28:06	84.83±0.33	M	1.50±0.03	30.60±0.72	20.45±0.42
						F	1.90±0.02	32.50±0.45	17.15±0.20
		b.	Parthenote	28:00	69.50±2.31	F	1.76±0.39	33.80±0.66	19.24±0.31
6.	$NB_7 \times NB_{18}$	a.	Bisexual	28:12	91.66±1.64	M	1.56±0.04	35.80±0.88	22.89±0.38
						F	2.03±0.02	39.60±0.57	19.49±0.17
		b.	Parthenote	28:00	71.00±1.44	F	1.64±0.03	30.50±0.76	18.65±0.30
7.	$NB_{18} \times NB_7$	a.	Bisexual	28:12	90.00±2.18	M	1.60±0.01	36.00±2.49	22.58±0.09
						F	2.04±0.03	38.50±2.16	18.80±0.07
		b.	Parthenote	28:00	70.33±1.45	F	1.67±0.01	31.20±2.64	18.64±0.07
8.	$NB_4D_2 \times KA$	a.	Bisexual	27:10	84.93±1.50	M	1.35±0.07	29.60±2.48	21.87±0.09
						F	1.67±0.02	30.70±1.79	18.39±0.04
		b.	Parthenote × Bisexual	27:02	81.60±0.83	M	1.36±0.03	29.70±0.62	22.93±0.27
						F	1.70±0.04	31.90±0.90	18.74±0.17
	Breed/Combination			a. CD at 5%			0.05	0.00	0.19
				b. CD at 1%			0.07	0.01	0.26
	Parthenote			a. CD at 5%			0.03	0.00	0.09
				b. CD at 1%			0.04	0.00	0.19

D : days, H : hours, M : males, F : females, and CD : critical difference.

TABLE 3. Heterosis over mid and better parent values of bisexual hybrids and hybrids resulting form female parthenote and bisexual males.

Combination/ Type	Larval duration	ERR	Cocoon weight	Cocoon shell weight	Cocoon shell ratio
$NB_7 \times NB_{18}$					
a. Bisexual	MPV + 6.54	+ 4.36	+ 6.39	+ 5.31	—0.03
	BPV + 8.57	+ 2.04	— 3.80	—6.45	—2.75
b. Parthenote × Bisexual	MPV + 0.07	+ 17.69*	+ 18.99**	+ 24.49**	+ 4.62**
	BPV + 2.97	+ 5.45	+ 14.25**	+ 20.55**	+ 4.18*
$NB_{18} \times NB_7$					
a. Bisexual	MPV + 6.54	+ 2.47	+ 7.76	+ 4.79	— 2.16
	BPV + 8.57	+ 0.19	— 2.57	— 7.46	— 4.70
b. Parthenote × Bisexual	MPV + 8.74	+ 16.57*	+ 21.75**	+ 27.35**	+ 4.62**
	BPV + 10.89	+ 4.45	+ 16.90**	+ 23.32**	+ 4.09

** — Significantly different ($P < 0.01$) and * — ($P < 0.5$)

parthenote and bisexual male (Table 3) were analysed, heterosis over MPV and BPV for ERR and cocoon characteristics was found higher in the hybrid resulting from a female parthenote and a bisexual male than in the bisexual hybrid of the respective breeds. The quantitative traits like cocoon weight and cocoon shell weight showed high level of hybrid vigour ($P<0.01$) when their mid and better parent values were compared with that of their respective parthenotes (Table 3). Similar high heterosis in different hybrids of *B. mori* was observed (TAKEI *et al.*, 1090). However no significant difference was observed in total laval span between parthenote and bisexual individuals.

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EFFICACY OF SOME INSECTICIDES TO CONTROL SHOOTFLY, DELPHACID, APHIDS AND LEAF SUGARY DISEASE IN SORGHUM

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The experiments were conducted with different insecticides to control shootfly, delphacids, aphids and leaf sugary malady (chikta) on CSH-8R and M-35-1 sorghum genotypes in *rabi* 1984-1985. Amongst the insecticides tried 3 sprays of quinalphos (0.05%) were effective in controlling the shootfly in CSH-8R. Delphacid population was controlled by all the chemicals than untreated control, except in carbofuran seed treatment in M-35-1. Aphid population was significantly controlled by quinalphos spray in M-35-1 than other chemicals under study. Cypermethrin (0.01%) 3 sprays controlled the chikta in both (CSH-8R and M-35-1) the genotypes.

(*Key words:* sorghum pests, control, chemical, insecticides, *Atherigona soccata*)

Sorghum is mainly grown under rainfed conditions in Maharashtra, over an area of about 65.77 lakh ha, out of which about 35 lakhs ha are cultivated in winter and rest in *kharif* season. However, average grain yields are higher (100 kg/ha) in *kharif* than in *rabi* season (400 kg/ha) (ANONYMOUS, 1984).

The *rabi* sorghum has to grow on residual soil moisture only. In addition to receding soil moisture, shootfly (*Atherigona soccata* Rond.), Delphacids (*Peregrinus maidis* (Ashmead), aphids (*Aphis sacchari* Z.), leaf sugary malady etc. play their role to reduce the grain yields of winter sorghum (APTE, 1958; CHUNDURWAR & KARANJKAR, 1979; MOTE, 1983). Annual losses to the extent of 10–15% due to leaf sugary malady have been reported by CHAVAN *et al.* (1959).

Very little information is available on grain yield losses due to these pests. Present investigations were therefore, directed to find out the relationship between the incidence of pests with grain yield and to control the pests and leaf sugary malady.

MATERIALS AND METHODS

Two field experiments were conducted for the control of shootfly, delphacids and aphids by chemicals during the winter of 1984–1985. Each experiment included twelve treatments arranged in R.B.D. replicated thrice (Tables 1 and 2). The plot size was 3 × 2.5 m. In one experiment, 'CSH-8R' was used and in another 'M-35-1'. Both the experiments were sown on 12.10.1984 by dibbling with 45 × 15 cm spacings. Fertilizer dose of 80 kg N/ha and 40 kg P_2O_5/ha was applied at the time of sowing.

Insecticides were applied (2 or 3 sprays as per treatment) at weekly intervals after one week of the emergence of 'CSH-8R' for the control of shootfly (Table 1). Observations on damage of shootfly was recorded on 28th day after emergence and presented as percentage of shootfly deadhearts.

In second experiment with 'M-35-1', insecticides were applied on 2.11.1984 (20th day after emergence) and on 10.11.1984 (28th day after emergence) for the control of delphacids. Similarly same treatments (Table 2) were repeated twice i.e., on 12.12.1984 (60th day) and 21.12.1984 (69th day) for the control of aphids. Observations on delphacid population on randomly selected five plants per plot and aphid population in 1 cm^2 on 3rd leaf from top of randomly selected 10 plants/plot of each replication were recorded each before application of insecticides and 48 h after the last spray of insecticides. The percentage of plants affected by leaf sugary malady

TABLE 1. Effect of chemical sprays on the incidence of shootfly, delphacids and leaf sugary disease on sorghum hybrid CSH-8R.

Treatment	Shootfly dead-hearts (%)	No. of delphacids/5 plant	Chikta affected plants (%)	Intensity grade of chikta	Grain yield (q/ha)
Endosulphon 0.05% 2 spray	10.70 (18.8)	4.6	72.92	4.6	35.13
Endosulphon 0.05% 3 spray	6.75 (14.3)	2.6	58.10	4.0	37.85
Oncol 0.05% 2 spray	10.85 (18.8)	4.3	62.57	4.3	40.56
Oncol 0.05% 3 spray	5.97 (14.8)	2.0	37.84	2.3	37.45
Cypermethrin 0.01% 2 spray	5.11 (12.3)	2.0	53.52 (47.0)	3.6	41.65
Cypermthrin 0.01% 3 spray	4.05 (11.4)	2.6	26.78 (31.8)	1.1	40.74
Quinalphos 0.05% 2 spray	7.78 (16.0)	6.0	76.94 (48.2)	4.6	32.98
Bromophos 0.05% 2 spray	4.98 (12.1)	3.3	64.08 (53.2)	4.0	34.88
Bromophos 0.05% 3 spray	6.89 (15.2)	5.0	52.75 (46.6)	3.3	38.19
Orthane 0.1% 3 spray	8.71 (20.9)	2.3	49.15 (44.5)	2.3	41.10
Control	18.53 (25.3)	3.3	85.43 (67.7)	5.0	24.76
S. E. ±	(1.8)	1.0	(2.51)	0.19	2.76
C.D . at 5%	(5.3)	N.S.	(7.36)	0.54	8.14

Values in parentheses are arcsin values.

and its intensity grade on second leaf from top were recorded on 22.11.1984. The intensity grades for leaf sugary malady were given as below; 1 = No appearance of leaf sugary malady; 2 = Exudate droplets upto 0.1 cm diameter; 3 = Exudate droplets between 0.1 to 0.5 cm diameter; 4 = Exudate drop between 0.5 to 1.0 cm diameter; 5 = Exudate drops spread up over more than 1 cm diameter. The plotwise grain yield recorded was statistically analysed.

RESULTS AND DISCUSSION

Application of different insecticides for the control of shootfly significantly reduced

TABLE 2. Effect of chemical sprays on the incidence of delphacids, aphids, and leaf sugary disease on sorghum genotype M-35-1.

Treatment	No. of delphacids/5 plants	No. of aphids/ cm^2	Chikta affected plants	Intensity grade of chikta	Grain yield (q/ha)
Carbofuran S. T. 5%	22.0	31.0	82.9 (66.5)	4.0	40.04
Carbaryl 0.2% spray	6.0	44.6	89.1 (56.3)	3.6	35.05
Dimethoate 0.03% spray	3.0	13.0	60.3 (51.0)	3.3	40.23
Quinalphos 0.05% spray	2.6	5.0	59.7 (50.6)	3.6	39.05
Cypermethrin 0.01% spray	1.3	36.0	35.6 (36.6)	1.8	37.03
Bromophos methyl 0.05% spray	1.6	24.6	60.1 (50.8)	3.6	37.37
Endosulphon 0.05% spray	3.0	29.3	58.11 (49.9)	4.1	31.89
Carbaryl 5% dust	2.3	42.3	63.2 (52.7)	4.0	36.08
BHC 10% dust	1.0	30.6	63.8 (53.4)	3.6	39.34
Carbaryl + BHC 10%	3.3	28.0	58.5 (50.0)	3.3	36.23
Kaolin 3% spray	7.6	34.6	68.6 (55.9)	4.0	34.66
Control	17.3	67.6	75.8 (61.9)	4.3	25.92
S.E. ±	2.02	5.9	(3.8)	0.3	2.37
C.D. at 5%	5.92	17.3	(10.6)	0.8	6.96

Figures in parentheses are the arcsin values.

the fly damage over control (Table 1). However, 3 sprays of quinolphos 25 EC @ 0.50% (T–8) recorded minimum deadhearts which were significantly superior to control (T–12), two sprays of endosulphon (T–1) and oncol (T–3). In winter season all chemicals under study showed significant control of shootfly, than untreated control (T–12). However, in *kharif* season JOTWANI (1982) reported that foliar application does not give satisfactory control even with most potent insecticide. Our own observations of last decade also show that under high pressure of shootfly, even carbofuran seed treatment was ineffective to control the shootfly damage satisfactorily. Differences in delphacid population, on 'CSH-8R', were nonsignificant in all the treatments. Percentage of plants affected by leaf sugary malady and its intensity was significantly less on 'CSH–8R', with 3 sprays of cypermethrine (T–6) than all other treatments.

In the experiment of 'M-35–1' (Table 2) delphacid population was significantly less in the plot applied with BHC 10% dust over carbofuran seed treatment (T–1). Kaolin spray (T–11) and untreated control (T–12). RATHORE *et al.* (1970) also reported similar observations. Aphid population was significantly less on quinalphos sprayed plants (T–4) than other treatments except, in dimethoate spray (T–3) which was on par with T–4 treatment. It is well known that delphacids and aphids can be satisfactorily controlled by the application of insecticides (DORGE & POKHARKAR, 1965; BORIKAR & DESHPANDE, 1978; POTE, 1975). In this experiment '(M–35–1)' differences in the percentage of plants affected with leaf sugary malady due to different treatments and the intensity grade had significant differences. Lowest % of plants affected and intensity grade was observed in cypermethrin spray (T–5).

In both the experiments the grain yield differences among the chemical treatment were on par with each other. However they were significantly superior to untreated control.

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VARIABILITY IN TOLERANCE TO SOME INSECTICIDES IN *APIS MELLIFERA* L. AND *APIS CERANA INDICA* F. COLONIES

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Studies undertaken on the variability in tolerance to endosulfan, HCH, fenvalerate and methyl parathion in 14 colonies of *Apis mellifera* L. and 6 of *Apis cerana indica* F. showed that one colony of *A.mellifera* was 2.15 times tolerant to endosulfan. *A. c. indica* has also showed 3 to 4 times tolerance to this insecticide. There was no correlation of LD_{60} of different insecticides with the fat content of bees of two *Apis* species.

(*Key words:* insecticide tolerance, *Apis mellifera* L., *Apis cerana indica* F.)

INTRODUCTION

Non-selective insecticides, though basic to modern agriculture, are detrimental to honeybees (ANDERSON & ATKINS, 1968). The development of insecticide tolerant/resistant strains is one way to overcome this problem and some tolerance to DDT, carbaryl, methyl parathion, permethrin and azinphosmethyl has been reported in field strains in *Apis mellifera* L. (ATKINS & ANDERSON, 1962; GRAVES & MACKENSON, 1965; TAHORI *et al.*, 1969; TUCKER, 1980; MALASPINA & START, 1983; DANKA *et al.*, 1986). Further, the development of tolerance to insecticides in any insect species is directly dependent upon the number of reproductive forms in the population exposed to a chemical in a given time span (GEORGHIOU, 1965). Therefore, studies were undertaken to screen out colonies of *Apis mellifera* L. and *Apis cerana indica* F for their variability in susceptibility to endosulfan, hexachloro-cylohexane (HCH), fenvalerate and methyl parathion. These insecticides were used for the studies because of their wide and frequent use against insect-pests of field and orchard crops in Himachal Pradesh (ATTRI & SHARMA, 1969; ANONYMOUS, 1984; 1986). Since susceptibility of insects to insecticides has indirect relationship with body fats (MUNSON & GOTLEIB, 1953; BEYE *et al.*, 1961; BENNET & THOMAS, 1963), fat contents of honeybees from different colonies were also compared.

MATERIALS AND METHODS

Outgoing foragers (more than 21 days old) of two *Apis* spp. were used for the studies. Two months before experimentation, honeybee colonies were equalised with respect to bee strength (*A. mellifera:* 7–8½ frames, *A. c. indica*: 4½–5 frames), brood (*A. mellifera*: 5 frames; *A. C. indica*: 2 frames) and food stores (*A. mellifera*: 2.000 kg, *A. c. indica* 1.000 kg) for conditioning them.

For determining contact toxicity to bees, technical grades of endosulfan, fenvalerate: HCH and methyl parathion were used. Out

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going foragers of two *Apis* spp. were captured at the hive entrance between 0900 and 0930 h and were immobilized at 5°C. One microlitre per bee of acetone-insecticide solution was applied to the thoracic tergum with micro-applicator (Burchard Manufacturing Co. Ltd., Rickmansworth, England). For each chemical, concentrations were adjusted to obtain mortalities between 10 to 90 per cent. A complete test for each insecticide finally consisted of three replications (10–15 bees per replicate) of each of 4–5 concentrations and the control. Control bees were applied with 1 μl acetone only. Cages with test bees were maintained at 26$\pm$ 1°C and 65$\pm$ 5% relative humidity. Treated bees were fed on 50% sugar syrup. Mortality counts were taken after 24 h. Bees unable to move or with unco-ordinated movements were counted as dead. Data for per cent mortality were corrected by ABBOTT'S (1925) formula and subjected to probit analysis (FINNEY, 1971). The quantity of insecticide in 1μl solution of each concentration was calculated to estimate LD_{50} value. Inter colony variation and tolerance ratio (TR) were calculated by dividing LD_{50} of the insecticide to bees of a colony with the lowest LD_{50} value among the colonies.

Fat content of bees (50 bees x 5 replicates/colony) were determined following TARHORI *et al.* (1969). The extraction was carried out in petroleum-ether (b p: 60–80°C). Fiducial limits of the LD_{50} values of insecticides were used to determine the differences in the susceptibility of bees from different colonies. Fat content between the *Apis* spp. were compared by Fisher's t- test. Coefficients of linear correlation (r) of LD_{50}s of insecticides with fat content were calculated with standard statistical method. (SNEDECOR, 1956).

RESULTS AND DISCUSSION

Variability in tolerance: The toxicity data of different insecticides for bees from different colonies of *Apis* spp. have been given in Table 1. Data show that *A. mellifera* bees from colony No. 5 are 2.15 times tolerant to endosulfan (LD_{50} differing statistically from other colonies except No. 6) as compared to colony no. 14. For other insecticides, LD_{50} values are at par among the colonies. Although level of tolerance to endosulfan in colony No.5 is low but in the absence of base line data for endosulfan and other insecticides, it is not possible to authenticate the degree of tolerance that this species has developed to these insecticide after its introduction in this country in 1962. Low levels of tolerance to endosulfan in colony No. 5 are undoubtedly due to an intercolony variation rather than selection. Low levels of tolerance (about 2 times) to DDT in two among 18 colonies of *A. mellifera* were also reported by TAHORI *et al.* (1969) and this was also believed to be due to inter colony variation. ATKINS & ANDERSON (1962) found that honeybees had developed resistance to DDT over the past few years and that the colonies gradually changed in their susceptibility to a given dose of DDT from 65 per cent to 15 per cent kill over an eight years period. Tucker (1980) found that selection for survival to carbaryl during nine generations produced resistance in newly emerged queens but only vigour tolerance in newly emerged worker bees. By 11th generation, the maximum screening done was quadrupled for queens and doubled for drones. Differences in tolerance to DDT among different colonies of Africanized and Italian bees (MALASPINA & START, 1983) and to azinphosmethyl, carbaryl methyl parathion and permethrin between Africanized and European bees (DANKA *et al.*, 1986) have also been reported.

TABLE 1. Colony variation in *Apis* species for their susceptibility to different insecticides.

Apis species		Endosulfan			H C H			Fenvalerate			Methyl parathion		
		LD_{50} (μg/bee)	Fiducial Limits	TR	LD_{50} (μg/bee)	Fiducial Limits (μg/bee)	TR	$LD_{50}\times10$ (μg/bee)	Fiducial Limits (μg/bee)	TR	$LD_{50}\times10$ (μg/bee)	Fiducial Limits (μg/bee)	TR
A. mallifera													
Col. No.	1	4.45	3.89—5.10	1.01	1.21	0.98—1.49	1.05	0.62	0.54—0.70	1.19	0.28	0.23—0.35	1.00
	2	6.11	4.97—7.52	1.38	1.33	1.11—1.60	1.16	0.63	0.56—0.71	1.21	0.42	0.35—0.50	1.50
	3	6.30	5.67—7.00	1.42	1.27	1.08 1.48	1.10	0.66	0.58—0.75	1.27	0.40	0.34—0.47	1.43
	4	4.86	3.98—5.92	1.10	1.32	1.03—1.68	1.15	0.68	0.53—0.87	1.31	0.42	0.35—0.52	1.50
	5	9.50	8.01—11.27	2.15	1.36	1.14—1.62	1.18	0.65	0.53—0.80	1.25	0.46	0.38 0.56	1.64
	6	7.62	6.20—9.35	1.72	1.36	1.08—1.70	1.18	0.63	0.56—0.70	1.21	0.54	0.41—0.70	1.93
	7	6.83	6.09—7.66	1.54	1.15	0.96—1.39	1.00	0.61	0.54—0.62	1.17	0.32	0.26—0.40	1.14
	8	5.87	5.20—6.62	1.33	1.50	1.20—1.88	1.30	0.61	0.60—0.62	1.17	0.45	0.36—0.56	1.61
	9	5.51	4.91—6.32	1.24	1.44	1.16—1.79	1.25	0.61	0.53—0.71	1.17	0.39	0.35—0.44	1.39
	10	6.15	5.88—6.43	1.39	1.35	1.10—1.66	1.18	0.52	0.45—0.60	1.00	0.40	0.33—0.50	1.43
	11	5.85	5.21—6.58	1.32	1.23	0.97—1.57	1.07	0.63	0.56—0.68	1.08	0.41	0.35—0.48	1.46
	12	5.08	4.39—5.86	1.15	1.32	1.07—1.63	1.15	0.62	0.47—0.83	1.19	0.39	0.28—0.55	1.39
	13	4.82	4.08—5.71	1.09	1.36	1.17—1.58	1.18	0.56	0.49—0.64	1.08	0.42	0.30—0.69	1.50
	14	4.43	3.73—5.26	1.00	1.21	1.20—1.23	1.05	0.61	0.49—0.74	1.17	0.43	0.36—0.50	1.54
A. cerana indica													
Col. No.	1	1.60	1.31—1.95	1.39(4.11)	0.41	0.32—0.53	1.05	0.11	0.08—0.14	1.00(1.22)	0.08	0.07—0.09	1.00
	2	1.15	0.94—1.40	1.00(2.97)	0.43	0.35—0.52	1.10	0.12	0.09—0.15	1.09(1.33)	0.08	0.07—0.09	1.00
	3	1.40	1.11—1.76	1.22(3.60)	0.39	0.30—0.51	1.00	0.13	0.11—0.17	1.18(1.44)	0.08	0.07—0.09	1.00
	4	1.34	1.08—1.67	1.17(3.54)	0.45	0.33—0.65	1.15	0.15	0.12—0.18	1.37(1.67)	0.08	0.07—0.10	1.00
	5	1.23	0.98 1.53	1.07(3.16)	0.40	0.30—0.50	1.03	0.11	0.08—0.12	1.00(1.22)	0.08	0.07—0.09	1.00
	6	1.58	1.31—1.91	1.38(4.06)	0.41	0.34—0.50	1.05	0.11	0.10—0.14	1.09(1.33)	0.08	0.06—0.10	1.00

Figures within parentheses are the tolerance ratios (TR) when compared with base line data for endosulfan ($LD_{50}=0.389$ μg/bee) and fenvalerate ($LD_{50}=0.009$ μg/bee) (Mishra and Varma, 1982).

There is no variability in susceptibility among 6 colonies of *A. c. indica* to the four insecticides. However, considering the results of MISHRA & VERMA (1982) as base line data (LD_{50} for endosulfan = 0.389 μg/bee), present results show that this species has developed tolerance to endosulfan and the tolerance levels in 6 colonies are 4.11, 2.94, 3.60, 3.45, 3.15 and 4.07 times more, respectively (Table 1). When present findings are compared with base line data for fenvalerate (MISHRA & VERMA, 1982; LD_{50}=0.009 μg/bee), 6 colonies of *A. c.indica* require 1.18, 1.35, 1.47, 1.63, 1.17 and 1.33 times more fenvalerate for LD_{50} (Table 1). These values being low and statistically similar show that this species has not yet developed any tolerance to fenvalerate. For other insecticides, there is no base line data against *A.c. indica* and thus present findings cannot be compared.

Results thus indicate that bees of two *Apis* have not developed any tolerance to HCH, fenvalerate and methyl parathion, and showed only low levels of tolerance to endosulfan. The development of tolerance/resistance to insecticides in honeybees through indirect exposure of queens and drones dividing several generations is undoubtedly a slow process and this has been expressed by either no or only low levels of tolerance to four insecticides in the two *Apis* spp. in the present findings. Therefore, for fruitful work in this area, methods for the exposure of great number of queens and/or drones to insecticides(s) will have to be developed.

Body fat content and its relationship with LD_{50} values of insecticides:

Fat content in 14 colonies of *A.mellifera* and 6 colonies of *A. c. indica* varied from 4.85 to 9.79 (Mean: 7.63%) and 4.63 to 7.98 (Mean:6.44%) per cent, respectively (Table 2). There is no report on the estimation of fat content in *A. c. indica* and, therefore, present results cannot be compared. Results on the fat content in *A. mellifera* are in agreement with ALBRECHT (1961), TAHORI *et al.* (1969) and RYAN *et al.* (1983) who reported 9.0, 9.15 and 7.54 per cent fat, respectively on dry weight basis but differ from BEYE *et al.* (1961) who reported comparatively higher fat content (on dry weight basis) for summer bees (12.2%) and winter bees (12.0%). Higher fat content (13.4%) was also reported by MUSZYNSKA (1974). The differences can be attributed to solvents used for fat extraction. Whereas a mixture of acetone and chloroform, and chloroform and methanol (2:1) were used for fat extraction by BEYE *et al.*

TABLE 2. Fat content of *Apis mellifera* (n = 14 colonies) and *Apis cerana indica* (n = 6 colonies) foragers and their correlation with the LD_{50}s for different insecticides.

Species	Fat (% of dry body weight)		Co-efficient of Linear correlation (r)			
	Mean ± SE_m	Range	Endosulfan	HCH	Fenvalerate	Methyl parathion
Apis mellifera	7.63 ± 0.37	4.85 — 9.79	+0.05	—0.09	+0.29	+0.04
A. cerana indica	6.44 ± 0.45	4.63 — 7.98	+0.42	+ 0.46	+0.44	+0.18
t (0.05)	1.08*					

* Non-significant at 18 degrees of freedom (Table value of t = 2.101).

(1961) and MUSZYNASKA (1974), respectively, petroleum ether (60–80° b p) was used in the present investigations. When two honeybee species were compared, they did not differ significantly in fat content. Data presented in Table 2 indicated that LD_{50}s of four insecticides against two *Apis* species did not show any significant correlation with fat content. Non-significant correlation of LD_{50}s of different insecticides with body fats can be attributed to the low variation recorded among the colonies for susceptibility to different insecticides. These findings are in agreement with BEYE *et al.* (1961) who found no relationship between insecticide resistant and fat content of summer and winter bees of *A. mellifera.*

Results on the variability in tolerance in 14 colonies of *A. mellifera* and 6 of *A.c. indica* to endosulfan, HCH, fenvalerate and methyl parathion thus show that one colony of *A. mellifera* is 2.15 times tolerant to enosulfan. *A.c. indica* has also shown 3 to 4 times tolerace to this insecticide. There was no correlation of LD_{50}s of different insecticides with the fat content of two *Apis* species.

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RELATIVE EFFICACY OF NEW GRANULAR FORMULATIONS AGAINST RICE HISPA *DICLADISPA ARMIGERA* OLIV.

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The efficacy of four new granular insecticides *viz.*, oncol, ethoprop, chlorpyriphos and cartap was tested under field condition against rice hispa *Dicladispa armigera* Oliv. and compared with carbofuran. The test insecticides registered significantly higher grub mortality (79.2 to 88.3%) than untreated control (38.4%) and were on par with carbofuran (80.4%). However, the grub parasitization was significantly lower (4.1 to 8.4%) in insecticide treated plots as compared to un-treated control (22.3%).

(*Key words*: *Dicladispa armigera*, granular insecticides, parasitization)

Rice hispa *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae) is one of the serious pests of rice in many rice growing tracts of India inflicting considerable leaf damage in early stages of crop growth. Adults scrape the chlorophyll content while grubs mine between two epidermal layers and feed on chlorophyll tissues.

In the absence of recognised resistant/ tolerant varieties, chemical control is the only dependable method to suppress this pest. KRISHNAIAH & KALODE (1983) reported that among 11 granular insecticides tested, only carbofuran exhibited high knockdown effect while mephosfolan indicated greater degree of persistent toxicity. BUDHARAJA *et al.* (1980) evaluated five granular formulations and found that carbofuran treated plots had no hispa populations throughout the experimental period. According to SUBBARATNAM & PERRAJU (1976) a single application of phorate granules at 7.5 kg a i/350 kg, seed/ha applied with rice seed could keep the seedlings free from hispa adults throughout the nursery period. The present study, was therefore, conducted to evaluate the effectiveness of some new granular insecticides under field conditions to find alternatives to carbofuran and phorate.

A rice field infested with hispa in DRR farm at Ramachandrapuram, was selected for the study during *Kharif*, 1985. Four new granular insecticides *viz.*, oncol, ethoprop, chlorpyriphos and cartap were included for evaluation along with standard check carbofuran. All the granules were broadcast in standing water (2.5 to 5.0 cm) @ kg a. i/ha only once at 20 DAT. The variety used was Sonasali. The field was divided into equal plots of 22.5 m^2 each. There were four replications. All the plots were separated by bunds to prevent water movement from one plot to another. Observations on the rice hispa damaged leaves on 10 random hills/plot were taken one day before and 20 days after application of the granules. The leaves with 25 per cent or more damaged area only were

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considered as damaged ones. Adult insects feeding on leaves were also counted on 20 hills/plot 7 days after treatment. One hundred damaged leaves from each plot were collected and dissected to assess percentage grub mortality and grub parasitization a week after granular application.

Rice hispa infestation one day before granular application was considered uniform, as the differences between plots were not significant (Table 1). Twenty days after treatment, the insecticide treated plots recorded 10.1 to 11.2 per cent damaged leaves (PDL) which were on par with standard check carbofuran (9.9 PDL) and significantly less than untreated control (27.4 PDL).

The data on live adults/20 hills showed that oncol, chlorpyriphos and cartap (7.2 to 7.7) were significantly better than untrated control (13.2) but, significantly less effective than standard check carbofuran (3.0); while ethoprop (11.2) was on par with control.

However, all the test insecticides registered significantly higher grub mortality (79.2 to 88.3%) than untreated control (38.4%) and were on par with standard check carbofuran (80.4%). The grub parasitization was significantly less (4.1 to 8.4%) in insecticide treated plots than untreated control (22.3%). The standard check carbofuran also recorded significantly lower grub parasitization (7.1%) than

TABLE 1. Efficacy of selected granular insecticides against rice hispa.

Insecticides	Per cent damaged leaves 1 DBT	Per cent damaged leaves 20 DAT	Adults (No/20 hills) 7 DAT	% GM 7 DAT	% GP 7 DAT
oncol 3 G	25.5[a]	10.6[b]	7.2[b]	79.2[b]	7.4[bc]
ethoprop (Mocap 10 G)	30.1[a]	10.1	11.2[c]	88.3[a]	4.1[a]
chlorpyriphos (Coroban 10 G)	26.2[a]	11.2[b]	7.7[b]	80.3[ab]	8.4[b]
cartap (Padan 4 G)	26.4[a]	10.1[b]	7.5[b]	83.0[ab]	7.5[bc]
carbofuran (Furadan 3 G) (Standard check)	27.9[a]	9.9[b]	3.0[c]	80.4[ab]	7.1[bc]
untreated control	25.2[a]	27.4[a]	13.2[a]	38.4[c]	22.3[a]

DBT = Days before treatment.
DAT = Days after treatment.
GM = Grub mortality.
GP = Grub Parasitisation.

Figures followed by common letter are not significantly different at $P=0.05$ according to LSD method.

NB : All the insecticides were broadcast in standing water @ 1.0 kg a.i./ha.

untreated control. Volatilization of soil applied insecticides might have killed or repelled the adult parasitoids of rice hispa grubs. Such volatilization was observed in case of thiocyclam hydrogen oxalate in rice against green leafhopper (KRISHNAIAH & KALODE, 1986).

Considering the leaf damage and grub mortality, all the test insecticides though exhibited performance similar to carbofuran, were less effective against adults. However, the adverse effects on grub parasitization seemed to be inevitable in epidemic situation for management of this pest through granular insecticides.

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RELATIVE RESISTANCE TO PYRETHROIDS IN CHILLI THRIPS, *SCIRTOTHRIPS DORSALIS* HOOD POPULATION IN ANDHRA PRADESH

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Three synthetic pyrethroids were bioassayed against nymphs of *Scirtothrips dorsalis* Hood representing populations from Guntur (GNT), Warangal (WGL) and Vizianagaram (VZM) in Andhra Pradesh, identified as areas of high, medium and low insecticidal use. Results indicated that VZM population of *S. dorsalis* was highly susceptible followed by WGL and GNT populations to all the three pyrethroids. In comparison with the most susceptible VZM population, development of resistance to fenvalerate, cypermethrin and alphamethrin respectively was 3.75, 4.55 and 4.10 times in GNT population and 2.17, 2.64 and 2.0 times in WGL population.

(*Key Words:* pyrethroid-resistance, *Scirtothrips dorsalis*, chillies)

INTRODUCTION

Of late, some field observations revealed that chilli thrips is requiring increasingly higher doses of insecticides for its control especially in areas where insecticidal pressure is alarming. Though development of pyrethroid-resistance in chilli pod borers, *Heliothis armigra* Hbn. and *Spodoptera litura* F. was well documented (Reddy & Prasad, 1991), no attempt has been made to assess resistance in chilli thrips to any pyrethroid in Andhra Pradesh and elsewhere in India. In order to fulfil this lacuna, a study was designed to evaluate relative resistance to three synthetic pyrethroids in chilli thrips, *Scirtothrips dorsalis* Hood collected from three different locations viz., Guntur (GNT), Warangal (WGL) and Vizianagaram (VZM) in Andhra Praesh known for high, medium and low pesticide use respectively.

MATERIALS AND METHODS

The cage for collection and rearing of thrips was constructed as per the specifications suggested by Beavers & Ewart (1971). Population of *S. dorsalis* on chillies was collected from the three locations in Andhra Pradesh and cultures representing GNT, WGL and VZM populations were maintained in the laboratory at 23 ± 2°C and 70 per cent RH.

Three commercial synthetic pyrethroids viz., fenvalerate (Starfen), cypermethrin (Ripcord) and alphamethrin (Festac) were bioassayed for their toxicity to nymphs of *S. dorsalis* populations. Tender chilli leaves were dipped in suspensions of different concentrations for each insecticide separately, air dried for one hour and introduced into rearing cage keeping the petiole turgid. Twenty nymphs from a homogeneous populations of *S. dorsalis* maintained in the cages were carefully transferred to the treated leaves. The treatment was replicated thrice using a total of sixty test subjects for each concentration. Similarly sixty test subjects were employed in the control treatment. Mortality counts were taken 24 hours after the treatment.

Data on per cent mortality corresponding to each concentrtion were corrected based on control mortality using Abbott's formula and were subjected to probit analysis according to FINNEY (1971).

The differential response of GNT, WGL and VZM populations to the same insecticide in terms of LC_{50} values was attributed to the development of resistance in one or two populations of *S. dorsalis* when compared with the most susceptible population. Resistance index was computed according to the formula suggested by FAO (1979) as follows:

$$\text{Resistance index} = \frac{LC_{50} \text{ of resistant strain}}{LC_{50} \text{ of susceptible strain}}$$

RESULTS AND DISCUSSION

Data on the dosage-mortality response of three populations of *S. dorsalis* to the three pyrethroids are presented in Table 1. The Chi^2 values indicated a good fit of probit regressions in all the bioassays. Comparison of LC_{50} values of each insecticide against nymphs of the three populations revealed that VZM populations exhibited the highest susceptibility to the pyrethroids. The GNT population manifested the least susceptibility while WGL population was intermediary in its susceptibility to the pyrethroids. In comparison with the most susceptible VZM population, GNT and WGL populations of *S. dorsalis* showed varying levels of resistance to the pyrethroids (Table 2). Relative-resistance to

TABLE 1. Probit analysis of dosage - mortality response of *S. dorsalis* populations to certain pyrethroids.

Insecticide	Sources of population	$Chi_{(3)}2$	Regression equation	LC_{50}	Fiducial limits (95%)	
Fenvalerate	GNT	1.8644	$Y = 3.1555 + 1.1163 x$	0.0045	0.0032	0.0063
	WGL	0.5193	$Y = 3.5066 + 1.0496 x$	0.0026	0.0019	0.0037
	VZM	0.8187	$Y = 3.6185 + 1.2915 x$	0.0012	0.0009	0.0016
Cypermethrin	GNT	1.4005	$Y = 2.9511 + 1.2085 x$	0.0050	0.0037	0.0067
	WGL	0.4665	$Y = 3.2898 + 1.1703 x$	0.0029	0.0021	0.0039
	VZM	0.6335	$Y = 3.7976 + 1.1719 x$	0.0011	0.0008	0.0015
Alphamethrin	GNT	1.2322	$Y = 3.1420 + 1.1584 x$	0.0041	0.0029	0.0057
	WGL	0.5974	$Y = 3.5283 + 1.1228 x$	0.0020	0.0014	0.0029
	VZM	0.5079	$Y = 3.9104 + 1.0896 x$	0.0010	0.0007	0.0015

GNT = Guntur; WGL = Warangal; VZM = Vizianagaram.

TABLE 2. Resistance levels in *S. dorsalis* populations of Guntur and Warangal to pyrethroids.

Sl. No.	Insecticide	Resistance index GNT Vs VZM	Resistance index WGL Vs VZM
1.	Fenvalerate	3.75	2.17
2.	Cypermethrin	4.55	2.64
3.	Alphamethrin	4.10	2.00

fenvalerate, cypermethrin and alphamathrin in GNT population was 3.75, 4.55 and 4.10 times, while in WGL population it was 2.17, 2.64 and 2.0 times respectively.

Cypermethrin-resistance in *Thrips tabaci* and *Frankliniella occidentalis* was earlier documented by FREULER & BENZ (1988). Overexposure to cypermethrin and fenvalerate and the kdr gene already present in the resistant populations due to selection for organochlorines, particularly DDT, in the past may be attributed to pyrethroid-resistance in GNT and WGL populations of *S. dorsalis* (MILLER & SALGADO, 1985; KASBEKAR & HALL, 1988). Presence of mixed-function oxidases and glutathione-s-transferases were said to be involved in pyrethroid resistance (PRABHAKER *et al.*, 1985; ARGENTINE *et al.*, 1989). Present studies focus on the need for judicious use of pyrethroids following the principles of insecticide resistance management.

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